VOLUME 29 NUMBER 1

NEXT MONTHLY MEETING, OCTOBER 8, 1907

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PROCEEDINGS

SEPTEMBER 1907

NEW YORK MEETING, DECEMBER 3-6, 1907

PHOTOGRAVURE & COLOR CO. N.Y.

CHARLES H. HASWELL

HONORARY MEMBER

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

SEPTEMBER 1907 VOL. 29 No. 1

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PROCEEDINGS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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1906-1907

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PROCEEDINGS

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 29 SEPTEMBER 1907 NUMBER 1

THE October Meeting, which will be held in the large auditorium of the Engineering Societies Building October 8, will be addressed by Prof. John P. Jackson of Pennsylvania State College on "The Relation of the College Technical Course to the Apprenticeship Course in Industrial Establishments." Other speakers interested in the subject will make short addresses and offer discussions, among whom are Prof. Dugald C. Jackson, of the Massachusetts Institute of Technology and President of The Society for the Promotion of Engineering Education, and Dr. Henry C. Pritchett, President of the Carnegie Foundation and President of the American Society for the Promotion of Industrial Education. The meeting will be open for general discussion.

The consolidation of the Mechanical Engineers' Library Association with The American Society of Mechanical Engineers will be presented for the action of the members at this meeting. The proposed merger has been approved by the Councils of both corporations, after due consideration and consultation as to the legal points involved.

The Society has been circularized and proxies distributed through July Proceedings empowering the President to cast the vote for the absent member. It is hoped that everyone will feel sufficiently interested to attend the meeting, or where that is impossible, to authorize the President to cast his vote.

THE NOVEMBER MEETING

The November Meeting Tuesday evening, November 12, will be devoted to the elevator of the modern high office building. Mr.

Charles R. Pratt will read a paper bearing especially on the elevators to be placed in the new Singer and Metropolitan Life buildings. Architects and engineers are invited to contribute discussion.

THE ANNUAL MEETING

The first of a series of papers on foundry practice, "The Foundry Department and the Department of Engineering Design," by Mr. W. A. Bole, appears in this number. Subsequent papers on specifications for iron, cupolas, blowers, moulding appliances, core ovens, crane service, and sand will be published in the several pre-convention issues of Proceedings.

Producer gas power plants and the utilization of low grade fuels in gas producers will be discussed at length by Prof. R. H. Fernald, Washington University, Mr. F. E. Junge, Berlin, Germany, and Prof. C. E. Lucke of Columbia University.

Railway train lighting by both gas and electricity will be the subject of a comprehensive article by Mr. Robert M. Dixon of New York and will be extensively discussed.

"ON THE ART OF CUTTING METALS"

Circulars were recently sent out to the membership announcing that a new edition of the Taylor paper "On the Art of Cutting Metals" bound in cloth had been printed by the Society. It has been suggested to us that we emphasize the point that the price of $3 for this new cloth bound edition applies to members and non-members alike. The sale of the book at this price is not limited to the members of the Society.

VOLUME 9 TRANSACTIONS

The Society desires to secure several copies of Volume 9 of the Transactions to supply requests from members. Anyone wishing to dispose of copies of this volume will confer a favor upon members who desire to make their set complete by advising the Secretary. Cash will be paid for volumes in acceptable condition.

JUNIOR BADGES

The attention of the Junior members is again called to the new badge, adopted by the Council, for the Junior grade. It is of the

same design as the member's emblem, except that the enamel is crimson instead of blue. The price is $3.25, and, if an exchange is desired, credit will be allowed for the old badge, according to its condition.

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RESIGNATION OF PROFESSOR GOSS

Dr. W. F. M. Goss, Dean of the School of Engineering at Purdue University, has resigned to accept the deanship of the Engineering Schools of the University of Illinois.

Professor Goss, a graduate of the Massachusetts Institute of Technology,—has been connected with Purdue since 1879, the time he began the organization of his department.

The members and guests who attended the Indianapolis Meeting will remember Professor Goss as the host at the very interesting and enjoyable session held at Purdue the last day of the convention.

COMPARATIVE TESTS

The United States navy is preparing for a comparative demonstration of the merits of the steam turbine and the reciprocating engine, and also for a comparison of the two types of steam turbines. The Birmingham and Salem, which are being built by the Fore River Ship Building Company, and the Chester, whose construction is under way at the Bath Me. Iron Works have been chosen for this triangular test.

The three vessels are being built from the same model, with similar boiler equipment and alike in every respect except that the Salem will have two shafts with a Curtis turbine on each, and the Chester four shafts with a high and low pressure Parsons turbine on two of them, and a cruising turbine on each of the others. The Birmingham will be equipped with reciprocating engines.

The results of this demonstration of the steam turbine and the reciprocating engine will doubtless be watched with a great deal of interest.

THE DEATH OF CHARLES HAYNES HASWELL

It is remarkable that during almost the same month in which the celebration of the one hundredth anniversary of the launching of the Clermont and the real founding of marine engineering was observed there should occur the death of the pioneer and veteran of the

engineering profession—Charles Haynes Haswell, who in boyhood saw the Clermont and Demologos, and in early manhood was the designer of the machinery of the second war steamer in the United States—the Fulton the Second. He was the first engineer officer to be appointed in our navy, and later became the first Engineer-in-Chief.

ORIGINAL DRAWING OF THE SECOND AMERICAN STEAMBOAT

The writing which appears very faint in the engraving of the original drawing of the second American steamboat was in pencil. On the left, immediately below the signature, the original reads:

> In building the boat it was found necessary to put the water wheel and cylinder six feet farther off than they are in the plan.

Immediately below the plan, on the left also,

> The boat is 327 tons custom house measurements.

On the right, between the elevation and the plan,

> The Sound Steamboat Fulton. The Sound steamboat is called the Fulton. She navigated the Sound between Long Island and Manhattan Island, passing the dangerous straight called Hell Gate, in which she is often exposed by a current running among rocks on every hand, at the rate of six miles an hour. She cost 87,000 dollars.

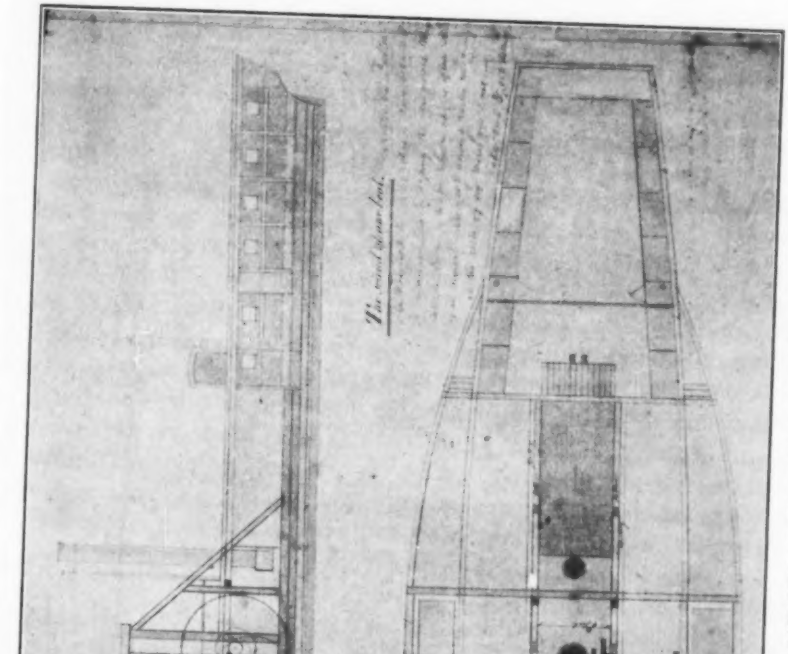
On the right, below the plan,

> Her boiler of copper cost more than 90,000 dollars.

ROBERT FULTON

The seventeenth of August 1907 marks an interesting centennial in engineering history. The steaming of the Clermont up the waters of the Hudson bearing its inventor on its triumphant deck opened the modern field of marine engineering and that commerce between nations which has done so much toward the advancement and diffusion of civilization.

It is said of Fulton by his biographers that to him belongs the distinction of the establishment of practical steam navigation. In epitomizing the work of a man in these days of cursory reading there is danger of minimizing its value. To say that Fulton is responsible for the commercial establishment of steam navigation expresses very inadequately his inestimable service, not only to his contemporaries in his own country, but to the succeeding generations of the civilized world.



ORIGINAL DRAWING OF THE SECOND AMERICAN STEAMBOAT WITH THE AUTOGRAPH OF ROBERT FULTON

The world's history might be divided into two ages; the first, where ocean barriers were wisely set by nature to the wanderings of the tribes and nations until such time when their development would be a guarantee of their fitness to repeople other lands; the second, when by reason of the intelligent utilization of the forces of nature they had overcome these barriers—thus demonstrating their development and power—then the inheritance of new countries became their reward.

As an instrument of that Providence which controls the ages Columbus stands preëminent, but it remained for Robert Futon to unite, by overcoming the obstacles of time and space, wind and tide, the civilizations which had touched, and to bring the swift interchange of science, art, and commerce—and as such, with Columbus, he may be regarded as a Man of Destiny.

It would be too much to say that had Robert Fulton not lived, or had he devoted himself to portrait painting—neglecting his practical creative and inventive genius, we would not enjoy the inestimable advantages of steam navigation at the present day. Other experimenters were at work who had attained a larger or smaller measure of success. Twenty years before Fitch had made successful trials with a boat propelled by steam in the waters of the Potomac, near Shepherdstown, W. Va., in the presence of General Horatio Gates and other eminent men. In 1785 James Rumsey, after a number of less successful experiments, demonstrated that a boat could be propelled by steam. He had previously greatly interested General Washington in its working model. So successful was his boat regarded that the legislatures of Virginia and Maryland in 1784 and 1785, respectively, granted him the exclusive right to navigate their rivers with his "newly invented steamboats."

Neither is it claimed that Fulton did not profit by the experience of others. His investigations were extensive, and he adapted the devices invented by experimenters along that and similar lines to his own needs. He did not build the steamboat from the ground up by the inventions of his own brain and hands, but using the instruments and devices available and combining them by the genius of his remarkable intellect, he established steam navigation as a fact of the age.

By reason of the combination in his personality of a genius for invention, a mathematical mind, a theoretical and practical mechanical knowledge and scientific methods, he developed the vague and imperfect ideas, and made steam propelled vessels an actual reality. It remained for Fulton, the patriot and philanthropist, to conceive that "The liberty of the seas will be the happiness of the earth," and

then for Fulton, the man of science, to set about the solving of the problems of steam navigation.

George W. Melville, Rear Admiral and Engineer-in-Chief of the U. S. Navy, Ret., upon the occasion of the memorial services held in Trinity Churchyard December 5 1901 said:

It is not likely after the lapse of history, when the merits of the different men who attempted to construct a commercially successful steamboat have been thoroughly sifted, that our patriotism would obscure our judgment, and that we should laud Fulton at the expense of others. It is sufficient to say that Fulton was aided in his work by the efforts and partial successes of those who had gone before him, and by the general scientific knowledge and engineering experience of his time, as well as by the acquaintance of some of the most able and enterprising men who were engaged in the solution of the world's problems, including Watt himself. . . . . But these advantages, of themselves, could not have insured the success which was the result of Fulton's progressive and courageous spirit, his adaptive and resourceful mind, his originality, practical judgment, and unremitting labor. Without doubt Fulton must be acknowledged to have made that valuable contribution to the world's progress—the commercial establishment of steam navigation. The claims of any man of any nation cannot take from the American engineer, Robert Fulton, the success which the unanswerable logic of his deeds awards him.

The advantage to Fulton of his lifelong friendship with Robert R. Livingston should be rightly estimated in any account of his life and work. Their friendship began at the time Livingston was minister to France, and was based upon congeniality of tastes and similarity of pursuits. It was Livingston who influenced Fulton to turn his attention to the study of steam as a means of navigation, and together they began experiments to test the practicability of their theory. The continuation of the experiments was left largely to Fulton, and in 1803 a trial of a boat built upon their plans demonstrated that their theory was entirely possible of success.

Inspired by patriotism Mr. Fulton and Mr. Livingston resolved to give the benefit of their discovery to America. Before leaving Europe Fulton placed an order for an engine with Watt and Boulton, Birmingham, England, and no further experiments were made until after his return to the United States.

The steaming of the Clermont up the Hudson to Albany, August 17 1807 marked the culmination of Fulton's indefatigable endeavor to solve a world problem. A letter written by Fulton himself upon this occasion will prove of interest.

My steamboat voyage to Albany and back has turned out rather more favorable than I had calculated. The distance from New York to Albany is one hundred and fifty miles; I ran it up in thirty-two hours and down in thirty. I had

a light breeze against me the whole way, both going and coming, and the voyage has been performed wholly by the power of the steam engine. I overtook many sloops and schooners beating to windward and parted with them as if they had been at anchor. The power of propelling boats by steam is now fully proved. The morning I left New York there were not, perhaps, thirty persons in the city who believed that the boat would ever move one mile an hour, or be of the least utility; and while we were putting off from the wharf, which was crowded with spectators, I heard a number of sarcastic remarks. This is the way in which ignorant men compliment what they call philosophers and projectors. Having employed much time, money and zeal in accomplishing this work, it gives me, as it will you, great pleasure to see it fully answer my expectations. It will give a cheap and quick conveyance to the merchandise on the Mississippi, Missouri and other great rivers which are now laying open their treasures to the enterprise of our countrymen; and although the prospect of personal emolument has been some inducement to me, yet I feel infinitely more pleasure in reflecting on the immense advantage that my country will derive from the invention.

The work of the inventor did not end with the successful operation of the Clermont. He began the construction of the Demologos, or Fulton the First, the first steam war vessel in the world, which was launched October 29 1814. Her first trial trip, June 1815, proved Fulton's theory that a heavy floating battery could be propelled by steam. It is interesting to note as an evidence of the moderation of Fulton's estimates that upon subsequent trials the speed of the vessel exceeded his guarantee to the government.

Fulton's triumph did not end with his works and his life. The Clermont stands as the herald of all river boats and oceanic liners, and the Fulton the First, as the ancestor of all the naval fleets of the world. Let us add the eulogy of Robert H. Thurston:

"To the inventor, the patriot, the statesman, we raise a monument. To the man, the engineer, the indomitable builder of the world's fleets—to the founder of modern civilization in a large measure, we render honor."

The celebration of the one hundredth anniversary of the first trip of the first successful steamboat was observed in New York harbor by the continuous blast for thirty seconds of every vessel carrying a boiler in the North and East rivers and in the upper and lower bays, and the ensigns of the boats of all nations were dipped.

DESCRIPTION OF THE CLERMONT OF THE NORTH RIVER

The Clermont of the North River was a flat bottomed boat with a poop deck four feet above the main deck and carrying two masts.

The foremast which was fitted with a trunnion at the bottom so

that it could be lowered in a head wind, carried a square sail, two topsails and a jib. The main mast carried a spanker and a topsail.

In a fair wind crew and passengers were expected to help set the mast and sails and the lee boards which were used to prevent drifting.

The copper boilers which burned about thirty cords of pine wood per trip, were capable of furnishing steam at nine inches pressure to the engine, which had been built by James Watt in England and imported by Mr. Fulton.

To turn around, one of the paddle wheels was uncoupled from the shaft.

The trip from New York to Albany took from twenty-six to thirty hours, and the fare was seven dollars.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both as to positions and as to men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 15th of the month. The list of men available is made up entirely of members of the Society and these are on file, with the names of other good men, not members of the Society, capable of filling responsible positions, information about whom will be sent upon application.

POSITIONS AVAILABLE

065 Position open for man with technical education and practical experience in mechanical work; competent to manage factory employing expensive tool makers and inexpensive factory hands. Brass drawing, designing, building automatic machinery and improving processes, and reducing cost. Executive ability necessary. Excellent opportunity for right man. Location, Illinois.

066 Large concern owning and operating various electric railway, gas and electric light and power properties in the Southwest has opening for a broad gaged young engineer as understudy to local superintendent of gas and electric plant. Some experience in similar work desirable but not required. Location, Texas.

067 Engineer and business man wanted to represent prominent concern in South America. Knowledge of Spanish requisite.

068 Professor of mechanical engineering in a prominent technical institution.

069 Instructor of machine design in university. Location, New York State.

070 Young mechanical engineer with experience in structural and smelter work in manufacturing company.

MEN AVAILABLE

104 Mechanical engineer several years' training, good technical education and practical experience in designing and building machinery desires position as instructor in mechanical engineering, machine

design, machine shop work etc., in a technical or trade school where executive ability would also be desirable.

105 An experienced mechanical engineer would take the New England agency for reliable power station apparatus or steam specialities.

106 Mechanical engineer, Yale, with extended experience in steam plant work, pumps and compressors, covering design, construction, selling, operating and cost keeping, desires to join engineering firm or force in large city. Will travel anywhere to sell or superintend work.

107 Member, technical graduate, ten years experience in estimating cost of laying out and superintending the construction of power plants and heating system, desires permanent position of responsibility. Special attention has been given to steam economy and maintenance of plants in operation. At present engaged in this work.

108 Technical graduate with experience as teacher and in development, construction and testing of new machinery, now in charge of mechanical department of a college, would like change of location, where executive ability and financial returns for student work is desirable. New York or vicinity preferred.

109 Mechanical engineer, manager, having disposed of interest in large foundry and machine shop, desires to represent one or more good lines of machinery in New York City.

110 Mechanical engineer of experience in designing and selling engines and mining machinery, open to engagement.

111 Mechanical engineer, Worcester Polytechnic, graduate with twelve years experience in designing engines and machinery wishes position as manager of concern making small engines or machinery in which a part interest could eventually be obtained. Now holds position of chief engineer with prominent engine manufacturing concern.

112 Member, graduate of Massachusetts Institute Technology, thirty six years old, twelve years experience in both steam and electrical engineering, desires a responsible position with a manufacturing, engineering or contracting company. Prefers to locate in Massachusetts.

113 Member, successful mechanical engineer, extensive practical experience in all branches of machine shop and manufacturing work,

desires position as works manager and change from present location: Boston, New York, or Philadelphia vicinities preferred. Good executive ability in organizing shops and cost systems, mechanically increasing product and reducing costs.

114 Works manager, chief engineer and executive engineer, graduate Yale and Cornell, desires position, preferably along electrical lines. Experience in prominent companies in United States and England.

115 Member, experience and study in machine and special tools wishes position in charge of shop equipment and design.

116 Junior member desires position. Graduate in mechanical engineering; experience in teaching, drafting, technical editorial work, and construction.

117 Technical graduate, age 32; married, desires position. Twelve years experience in drafting and as erecting engineer on waterworks machinery, air compressors and large gas engines.

118 Member, experienced as mechanical engineer, district manager, and engineer salesman, desires to make a change.

119 Junior member desires position as sales engineer, sales manager or assistant for company in general engineering field.

120 Technical graduate; five years experience in heating, ventilating and mechanical draft systems; installation of engines, pumping machinery, blowers, etc. Charge of branch for two years; desires position as mechanical engineer or assistant mechanical engineer with railroad or other corporation.

121 Mechanical engineer, 14 years experience, desires position in or near Philadelphia as condenser expert, construction engineer, or representative.

122 Junior member 30 years of age desires position. Has had three years shop experience, four years drawing room designing steam engines and general machinery, and three years with engineering company designing and superintending construction of steam and hydro-electric power plants, also experience in concrete construction.

123 Member, technical graduate, 10 years varied and practical experience especially of mining and ore treatment machinery and contractors plant, four years with European branch of American house, now in New York with contracting firm, desires change from

executive to sales department. Prefers to sell mining machinery or represent American firm in Europe or elsewhere. Good address: corresponds in French and Spanish.

124 Position as superintendent, general superintendent or works manager wanted by a member desiring change. A thorough practical man, with an exceptional record as cost producer. A clean record as to character. Extensive experience in special and automatic machinery, gas, gasoline producer and producer engines. Steam pumps and hydraulics.

CHANGES OF ADDRESS

ADAMS, Thomas D. (Junior, 1906) Southport, Conn.

ALEXANDER, Arthur Thomson (Junior, 1905) Mgr. Alexander & Co., P. O. Box 347, Port Elizabeth, South Africa,

ALEXANDER, Chas. A. (1899;1905) Mech. Engr., German-American Button Co., Rochester, and for mail, Batavia, N. Y.

ARMSTRONG, Walter Jonas (Junior, 1907), Draftsman, Jeffrey Mfg. Co., and for mail, 319 Buttles Ave., Columbus, Ohio.

ARNOLD, G. L. H. (1899) P. O. Box 1, Stamford, Conn.

AROZARENA, RAFAEL M. de (1885) Life Member, Engr., and Contr., 3a Calle De Las Estaciones No. 1, City of Mexico, Mexico.

BAGG, Samuel F. (1896) Box 2799, Boston, Mass.

BAILEY, W. H. (1881;1890) Agent, Am. Tube Wks., 20 Gold St., P. O. Box 1, and 200 West 57th St., New York, N. Y.

BARTLETT, Geo. B. (1888) Chief Draftsman, Illinois Steel Co., Joliet, Ill.

BASFORD, Geo. M. (1889;1891) care of American Loco. Company, 111 Broadway, New York, and for mail, 134 Primrose Ave., Mt. Vernon, N. Y.

BATTEN, Percy H. (Junior, 1901) P. H. Batten & Co., Suite 404, 145 La Salle St., and for mail, 54 Walton Pl. Chicago, Ill.

BELL, John Everett (Associate, 1903) Engr., care of Babcock & Wilcox Co., 85 Liberty Street, New York, N. Y.

BENDIT, Louis (Associate, 1905) Pres. and Mgr., Bendit M. E. Co., 1300 W. 11th St., Kansas City, and 134 W. Sea Ave., Independence, Mo.

BERLINER, Richard W. (Junior, 1903) 174 West 79th St., New York, N. Y.

BISSELL, Geo. W. (1890; 1899) Prof. Mech. Eng'g and Dean of Eng'g, Michigan Agricultural College, and for mail Agricultural College P. O., Mich.

BITTERLICH, Walter J. (Junior, 1906) Designer, United Shoe Mchy. Co., and for mail, P. O. Box 923, Beverly, Mass.

BORDEN, Wm. H. (Junior, 1905) Goldsboro, North Carolina.

BOUGHTON, Judson H. (Junior, 1903) Secretary and Treasurer, National Light and Improvement Co., Pierce Building, St. Louis, Mo.

BREEN, James (Associate, 1893) Bingham Consolidated Mining and Smelting Co., Room 700, McCornick Block, Salt Lake City, Utah.

BRODHEAD, Alex. L. (Junior, 1900) Mech. Engr., care of Atlas Portland Cement Co., Northampton, Pa.

BULKLEY, J. Norman, (1902) Chief Engr., United Eng'g Co. (Ltd.), Box 1082, Johannesburg, South Africa.

BURNHAM, Harry A. (1898; 1902) 181 Cabot St., Newton, Mass.

BURTON, Frank H. (1900) 275 Grove St., Montclair, N. J.

CAIRD, Robert (1884) Managing Director, Caird and Co. (Ltd)., and for mail 56 Esplanade, Greennock, Scotland.

CARNEGIE, Andrew (1890; Honorary, 1907) 2 E. 91st St., New York, N. Y.

CASE, Albert H. (Junior, 1903) Supt. Sante Fe Gold and Copper Mining Co., San Pedro, New Mexico.

CHAMBERLAIN, Harry Maynard (1907) Newport, Vermont.

CHAMBERS, Frank Ross, Jr. (Junior, 1898) Mech. Engr., Couch Bldg., and 803 Marshall St., Portland, Oregon.

CHANDLER, Sellers McKee (Junior, 1905) Pittsburg Supply Co., 449 Water St., Pittsburg, Pa.

COOK, John P. (Junior, 1906) Draftsman 111 N. Terrace Ave., Mt. Vernon, N. Y.

COX, Frank Gardner (Junior, 1905) Engr., Otis Elevator Co., 17 Battery Place, New York, N. Y.

CRAWFORD, David Francis (1899) Genl. Supt. M. P., Penn. Lines, Union Sta., Pittsburg, Pa.

CROFOOT, George Emerson (Junior, 1907) Instr. in Mech. Eng'g, University of Pennsylvania, Philadelphia, Pa.

CURTIS, Edma H., Jr. (Junior, 1901) Draftsman, Pittsburg Plate Glass Co., Pittsburg, Pa., and for mail, Crystal City, Mo.

DAVIS, Francis H. (1902) 5 Watts Bldg., and for mail, East Lake P. O., Birmingham, Ala.

DAVIS, Herbert Rowan (Junior, 1901) 605 Scarritt Bldg., Kansas City, Mo.

DELANY, Charles Henry (1907) Office Engr., Stirling Consolidated Boiler Co., and for mail, 336 Sixth St., Barberton, Ohio.

DIXON, Horace (1904; 1906) Mech. Engr., Pres. Dixon Steam System Co., Chicago, Ill., and Dixon and Heydorn, London, and for mail, 88 St. James St., London, S. W., England.

DREYFUS, Edwin D. (Junior, 1905) C. D. Benedict and Co., 470 Old Colony Bldg., Chicago, Ill.

DUDLEY, Samuel William (Junior, 1904) Mech. Engr., Westinghouse Air Brake Co., Wilmerding Pa.

DURLEY, Richard John (1899) Prof. Mech. Eng'g, McGill University, and 20 Summerhill Ave., Montreal, Canada.

EILERS, Karl Emrich (1890; 1904) Am. Smelting and Refining Co., 71 Broadway, New York, and for mail, Sea Cliff, Long Island, N. Y.

ELLIOT, Elmer G. (1907) Constr. Engr., Selby Smelting and Lead Co., Selby, Cal.

ENNIS, William Duane (Junior, 1898) Prof. Mech. Eng'g, Polytechnic Institute, Brooklyn, N. Y.

FAIRBANKS, Adolphe S. (1899; Associate, 1904) Crosby Steam Gage and Valve Co., 16 Dey St., New York, N. Y.

FARRAR, Edward (1907) Cons. Mech. Engr., Genl. Mining and Finance Corp. and for mail, Box 1242, Johannesburg, Transvaal, S. A.

FAWCETT, Wallace H. (Junior, 1903) Washington Water Power Co., Spokane, Washington.

FRANCIS, W. H. (1884) Trust Co. of North America, 503 Chestnut St., Philadelphia, Pa.

GAZZAM, Joseph P. (1902) Life Member, 514 Security Bldg., St. Louis, Mo.

GIBSON, Arthur (1892) Mech. and Civil Engr., 12–14 First Ave., and for mail P. O. Box 200, Nome, Alaska.

GILLIES, Wm. F. (Junior, 1905) Ingersoll-Rand Co., El Paso, Texas.

GLEASON, Gilbert Howe (Junior, 1906) The Green Fuel Economizer Co., 702 Oliver Bldg., Boston, Mass.

GOODRICH, Robert R. (1903) Columbus Borax Company, Lebec, P. O., Kern Co., Cal.

GORTON, John C. (1897; 1899) Cons. Engr., Park Hotel, Warren, Ohio.
GRIMSHAW, Frederick G. (Junior, 1901) West Jersey and Seashore R.R., and for mail, 313 N. 2d St., Camden, N. J.
HALE, Herbert Carlton (1904) Contr. and Designing Engr., 1036–38 Schofield Bldg., Cleveland, Ohio.
HAMMARBERG, Arndt L. (1901) Chief Engr., Stora Kopparbergs Bergslag, Falun, Sweden.
HAMNER, Chas. Sutherland (1901) Hamner & Lilienthal, Havana, Cuba.
HANSON, Walter S. (Associate, 1902) Gen. Mgr., Orient Cotton Products Co., 101 Bryant Bldg., and for mail 3409 Wyandotte St., Oklahoma City, Okla.
HARGRAVE, Russell William (Junior, 1899) 212 N. Mills St., Madison, Wis.
HARMAN, John J. (Junior, 1906) Western Tube Co., Kewanee, Ill.
HASKELL, Geo. O. (Junior, 1899) The Southern Cotton Oil Co., 24 Broad St., New York, N. Y.
HAY, Alex. Stanley (Junior, 1891) Cons. Mech. Engr., Rooms 17–19 International Bldg., Yokohama, Japan, and for mail, Stirling Boiler Co., 25 Victoria St., Westminster, London, England.
HEAD, Francis (1906) 109 W. Chelter Ave., Germantown, Philadelphia, Pa.
HEDEMANN, Christian J. (1904) Honolulu Iron Works Co., Honolulu, Hawaii, and 11 Broadway, Room 1113, New York, N. Y.
HENRY, Geo. J., Jr. (1901) care of Pelton Water Wheel Co., 90 West St., New York, N. Y.
HESS, Howard D. (1903) 132 Erie St., Johnstown, Pa.
HODGE, Geo. O. (Junior, 1904) N. Y. Car and Truck Co., Kingston, N. Y.
HUMPHREY, Orman B. (1907) Cons. Engr., 202 Exchange St., and for mail, 63 Grove St., Bangor, Me.
HURD, Chas. H. (1902) Supt. Water Works, Indianapolis Water Co., and 2037 N. Alabama St., Indianapolis, Ind.
IRELAND, M. L. (Junior, 1902) 1st Lieut. Ordnance Dept., U. S. Army, Frankford Arsenal, Philadelphia, Pa.
JACKSON, Arthur C. (Junior, 1903) Secy. and Treas. of Miller Lock Co., 4523 Tacony St., and for mail, Adams Ave. and Orthodox St., Frankford, Philadelphia, Pa.
JACOBUS, Robert F. (Junior, 1907) Asst. Ch. Engr., American Tobacco Co., 111 Fifth Ave., New York, N. Y. and for mail, Ridgefield, N. J.
JOWETT, J. H. (1907) Mgr. Ingersoll-Rand Co., 11 Broadway, New York, N. Y.
KALES, Wm. Robert (Junior, 1894) Chief Engr., Whitehead & Kales Iron Works, Randolph and Franklin Sts., and for mail, 195 Burns Ave., Detroit, Mich.
KINGSBURY, J. G. (1906) Pres., Grant Mfg. and Mch. Co., 90 Silliman Ave., Bridgeport, Conn, and 49 Mitchell St., Orange, N. J.
KWANG, Kwong Yung (1899) Life Member, Dir. and Engr., Lin-Cheng Mines, Lin-Cheng Lu-Han Railway, via Peking, North China.
LELAND, Wm. Emmons (1904) Cons. Engr., 939 Merchants Exchange, San Francisco, Cal.
LEWIS, Wm. Y. (1902) Mgr., Erecting Dept., International Steam Pump Co., 114 Liberty St., New York, and for mail, 301 Barclay St., Murray Hill, Flushing, N. Y.
LIEB, John W., Jr., (1886) 3d Vice Pres. and Associate Genl. Mgr., The New York Edison Co., 55–57 Duane St., New York, N. Y.
LINCOLN, Paul Martyn (1907) Engr., Power Div., Westinghouse Elec. and Mfg. Co., and for mail, P. O. Box 911, Pittsburg, Pa.

LOCKWOOD, Rutherford T. (Junior, 1904) Engr., Sone & Fleming Works, Kingsland and Meserole Aves., Brooklyn, N. Y.

LOUER, Lewis S. (Associate, 1900) Western Mgr., "Engineering Record," 590 Old Colony Bldg., Chicago, Ill.

LYLE, Joel Irvine (1906) Mgr., N. Y. Branch, Buffalo Forge Co., and Buffalo Steam Pump Co., 39 Cortlandt St., New York, N. Y.

LYMAN, Elihu Root (Junior, 1904) 154 Hanover St., Fall River, Mass.

LYONS, James W. (1902) Pres. Lyons Boiler Works, DePere, Wis.

McBAIN, William Coryell (Junior, 1904) 908 Ramsey St., Wilkinsburg, Pa.

McELROY, Jos. A. (1895) Director, Macartney, McElroy & Co., Ltd., Caxton House, S W., London, England, and for mail, 29 West 39th Street New York.

McEVOY, Dermot (1906) 70 St. Matthews Street, Montreal, Canada.

McLEAN, Robert Walter (Junior, 1907) The Carver Cotton Gin Co., East Bridgewater, Mass.

MACINTIRE, Horace James (Junior, 1907) National Lead Co., 135 Marshall St., Brooklyn, N. Y.

MAROT, Edward H. (Junior, 1903) General Delivery, Newark, N. J.

MORFORD, Thomas E. (1902) Mgr., New York Office, American Steam Pump Co., 17 Battery Pl., and 13 East 22d St., New York, N. Y.

MORGAN, Ralph L. (1900; 1902) Idlewood Club, Lake View, Erie Co., N. Y.

MOSELEY, Alexander Willett (1900) Prof. Applied Mechanics, Head Dept. of Mech. Eng'g, Lewis Institute, Chicago, Ill.

MUNBY, Ernst J. (1906) Engr. and Dir. Auriferous Pyrites By-Products Co., Constr. Dept., Hudson Companies, New York, N. Y., and Baddon Park, Essex, England, and for mail, 344 W. 23d St., New York, N. Y.

MURPHY, Benjamin Stewart (Junior, 1905) 254 Fourth St., Jersey City, N. J.

NAEGELEY, John C. (1901) Engr. and Architect, 301 Lexington Ave., Buffalo, N. Y.

NAGLE, A. F. (1880) Mech. Engr., 22 S. High St., Bethlehem, Pa.

NEVILL, David J. (1900) Mech Engr., Stearns Roger Mfg. Co., Denver, Colo.

NICKEL, Franz F. (1899) Cons. Engr., 150 Nassau St., New York, N. Y., and for mail, 27 Winans St., East Orange, N. J.

NOYES, Henry (1899) Life Member; Noyes Bros., 153-7 William St., Melbourne, and Holmby Malvern, Victoria, Australia.

PEIRCE, Arthur W. K. (1903) Victoria Falls Power Co., Ltd., Johannesburg, and for mail, P. O. Box 217, Germiston, Transvaal, South Africa.

PENRUDDOCKE, J. H. (1889) Asst. Loco. Supt., Uganda Railway, Nairobi, British East Africa.

PERKINS, George Howard (Junior, 1900) Lockwood, Greene & Co., 93 Federal St., Boston, Mass.

PINGER, Geo. C. (Junior, 1907) The Wm. Tod Co., and for mail, 352 Arlington St., Youngstown, Ohio.

PROAL, Arthur B., Jr., (1905) Robins Conveying Belt Co., 2600 Park Row Bldg., New York, N. Y.

REEVE, Sidney A. (1901) Cons. Engr., Rotary Meter Co., 280 Broadway, New York, N. Y.

REUNERT, Theodore (1901) Engr., Reunert & Lenz, Engrs., Box 92, Johannesburg S. Africa, and care of Findlay, Durham & Brodie, 110 Cannon St., London, E. C., England.

RICHARDSON, Clifford (Associate, 1894) New York Testing Laboratory, Maurer, N. J.

RICKER, Wm. Wood (1906) Guarantee Construction Co., 90 West St., New York, N. Y.
ROGERS, Charles Edward (Associate, 1898) Australian Mgr., Fraser & Chalmers, Ltd., of London, Kalgoorlie, W. Australia.
ROPER, Norman Brownell (1905) Engr. and Salesman, Power and Mining Mchy. Co., Cudahy, Wis.
RUCKES, Joseph J., Jr. (Junior, 1902) 1336 Bristow St., New York, N. Y.
RUST, William F. (1904) Asst. Engr., American Sheet and Tin Plate Co., Frick Bldg., Pittsburg, Pa.
SAGUE, James Edward (1887) Public Service Commission, Albany, and New Hamburg, N. Y.
SCARBOROUGH, Francis Winthrop (1905) Cons. Engr., 816 Mutual Bldg., Richmond, Va.
SCHAKEL, Jacob Daniel (Associate, 1907) Otis-Fensom Elevator Co., Ltd., Box 253, Hamilton, Ontario, Canada.
SCHNEBLE, Rudolph G. (1897) Engr'g Dept., National Cash Register Co., and 24 N. Harshman St., Dayton, Ohio.
SLICHTER, Walter I. (Junior, 1902) Elec. Engr., Genl. Elec. Co., and for mail, 7 Glenwood Blvd., Schenectady, N. Y.
SMITH, Geo. Marshall (Associate, 1904) Resident Engr. for Julian Kennedy, Wickwire Steel Co., 1027 White Bldg., Buffalo, N. Y.
SMITH, Wm. Edward (1900) Genl. Mgr., Société Anonyme, Westinghouse, Nevski Prospeck No. 11, and for mail, Strelna, St.Petersburg, Russia.
SNOW, Walter B. (1898) 29 Russell Ave., Watertown, Mass.
STARKWEATHER, William G. (1897) Allis-Chalmers Co., State Mutual Bldg., Boston, Mass.
STEBBINS, Theodore (1903) J. G. White & Co., 43 Exchange Place, New York, N. Y.
STEVENS, Robt. H. (Junior, 1903) Draftsman, Genl. Chemical Co., 25 Broad St., New York, and for mail, 806 Washington Ave., Brooklyn, N. Y.
SUMNER, Harry W. (Junior, 1900) Rainier Foundry Co., P. O. Box 56, and Lincoln Hotel, Seattle, Wash.
SZE, S. C. Thomas (Junior, 1905) 654 Peeble St., Wilkinsburg, Pittsburg, Pa.
TENNEY, Albert Ball (1896; 1904) Genl. Mgr., 137 Pleasant St., Malden, and 111 Tremont Ave., Everett, Mass.
THOMPSON, David (1905) Mining and Cons. Engr., Box No. 9, P. O., Castlemaine, Victoria, Australia.
THOMPSON, Edward P. (1884) 39 Cortlandt St., and for mail, 50 Morningside Ave., West, New York, N. Y.
TOWNSEND, Harry P. (Junior, 1904) Secy. and Genl. Mgr., H. P. Townsend Mfg. Co., 32 Union Pl., and for mail, P. O. Box 342, Hartford, Conn.
TRACY, Theron H. (1902) Pres't and Mgr., Tracy Engineering Company, 66 Beaver Street, New York, N. Y.
TRAMPE, J. Adam C. L. de (1904) Saranac Lake, N. Y.
TUTTLE, Willard S. (1900) Vice Pres. Phila. Hardware and Malleable Iron Works, 9th and Jefferson Sts., and 227 W. Hortter St., Phila., Pa.
WALDO, Leonard, (1894) Cons. Engr., Room 802 Atlantic Bldg., 49 Wall St., New York, N. Y., and for mail 640 W. 8th St., Plainfield, N. J.
WALLIS, James T. (1901) Supt. of M. P., P. E. & C. Ry., Williamsport, Pa.
WASHBURN, William S. (1891) Campello Station, Brockton, Mass.

WATSON, Geo. L. (Junior, 1905) Civil Cons. Engr., 1224 W. Allegheny Ave., Philadelphia, Pa.

WEBSTER, William R. (1889) Cons. and Inspecting Engr., 411 Walnut St., Philadelphia, Pa.

WEBSTER, William Reuben (Junior, 1893) Genl. Supt., Bridgeport Brass Co., and for mail 208 Brooklawn Ave., Bridgeport, Conn.

WIDDICOMBE, R. A. (1898; 1906) Eng. and Supt., Kroeschell Bros. Co., and for mail, 2573 Lakewood Ave., Edgewater Sta., Chicago, Ill.

WILLIAMSON, Wm. C. (1882) 1800 N. 16th St., Philadelphia, Pa.

WILSON, L. G. (1903; Associate, 1907) Mech. Engr., J. G. Wilson Mfg. Co., 3 West 29th St., New York, N. Y., and for mail Virginia Club, Norfolk, Va.

WINTER, Oscar (1906) Steam Engr., 410 Rockefeller Bldg., Cleveland, Ohio.

THE FOUNDRY DEPARTMENT AND THE DEPARTMENT OF ENGINEERING DESIGN

By WILLIAM A. BOLE, PITTSBURG, PA.
Member of the Society

These notes have special reference to the design and manufacture of large and complicated castings; castings in which the material must be intrinsically strong and in which all of the various elements of a complicated casting must work harmoniously to accomplish the engineering purpose intended.

2 Small castings, as a rule, require much less consideration for two reasons; first: It is not usual to demand high strength in small iron castings because the designer will usually make a section thick enough to permit of pouring the metal—obtaining this information either from his own observation or by the foundryman's advice—and for most small objects the sections thus determined are more than ample for considerations of strength. Second: Thin castings, by virtue of their more rapid cooling, are almost certain to be stronger per unit section than would be the case if the same metal were poured into larger and heavier shapes.

3 Many large iron castings are I believe of questionable strength and of doubtful reliability, even though they have not as yet broken in service, because of internal strains and lack of harmony between their constructive elements. This may be true even though the casting is poured out of iron of the best quality, and may be due to inconsistencies of design occasioned by lack of experience on the part

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of the designer especially in the cooling and shrinking of the various parts of a large casting after being poured.

4 The physics of cooling, shrinking and synchronous contraction is a study which the foundryman should be better able to follow, and to become expert in, than the designer; and the engineering department of a manufacturing plant making large iron castings of complicated shapes, would do well to consult foundry conditions very carefully before finally determining upon and accepting designs for such castings.

5 The foundryman's knowledge of the physics of the foundry should qualify him to anticipate some things not generally known to the average draftsman, and often not known to the supervising engineer.

6 The usual drawing room method is one of making assumptions in design by which sections of castings are regarded as beams of various sorts, loaded in various ways, as pillars, as sections in tension and sections in compression, etc. These assumptions are made as though the said members and said sections were of cold materials, put together in such a manner as to allow each section to remain normal to itself, as would be the case in building up a bridge truss, securing member to member by rivets or pins. Unfortunately for such assumptions the casting must go through the stages of molten, red hot and cold conditions before it is in its final form, and what happens during these changes of state may entirely upset the engineering assumptions upon which its members were calculated, and when the casting is cold, some members which were expected to be in tension may be in compression, and *vice versa,* others that had been intended for compression may be actually in tension. It is therefore necessary in designing to consider carefully whether the casting, after having passed through these formative stages, will ultimately be as the designer assumes.

7 Castings are often designed with a useless multiplicity of ribs, walls, gussets, brackets, etc., which by their asynchronous cooling and their inharmonious shrinkage and contraction, may entirely defeat the intention of the designer. He may find some of his walls, ribs, or brackets cracked before the casting is cleaned. It is sometimes possible to remove such superfluous walls, ribs and brackets, and thereby obtain not only a lighter but a stronger and more dependable casting.

8 It is highly essential that the designer keep in mind, as nearly as he can imagine, the cooling processes through which the casting must pass, and the effect which will be produced upon any given

wall or member of the casting if it is cooled faster or slower than the other parts of the same casting. It would be difficult to set down any considerable number of rules governing this matter, but it may be of advantage to call attention to the necessity for careful study of this and of related subjects.

9 The outer walls of a casting, that is to say those which are more nearly adjacent to the sides and radiating surfaces of the flask, are naturally the first parts of a casting to lose heat, to fall in temperature, to begin to contract and decrease all their linear dimensions. The inner walls of the same casting, being more isolated from the outer and conducting surfaces of the flask, may remain hot for a much longer period than the outer portions; as a consequence the outer members of certain castings may cool and take on their ultimate dimensions while the inner members are still very hot. The latter will, of course, ultimately cool off by conduction, but they will also continue to contract until at normal temperature, and their freedom of contraction may be prevented by the already determined dimensions of the outer walls; as a result there is likely to be violent tension strains in the interior walls of such castings. Sometimes these strains are sufficient to cause rupture while the casting is still in the mold; sometimes the casting does not rupture until it is out in service, and even if it breaks in service the rupture may not be produced by stresses of engineering design, but may be due to the original asynchronous cooling of the various parts of the casting.

10 There are some castings which, by virtue of their shapes, can be specially treated by the foundryman, and artificial cooling of certain critical parts may be effected in order to compel such parts to cool more rapidly than they would naturally do, and the strength of the casting may by such means be beneficially affected. As for instance in the case of a flywheel with heavy rim but comparatively light arms and hub; it may be beneficial to remove the flask and expose the rim to the air so as to hasten its natural rate of cooling, while the arms and hub are still kept muffled up in the sand of the mold and their cooling retarded as much as possible. Or in the case of a flywheel with an ordinary weight of rim and arm but with a heavy hub; the hub may be exposed and compelled to cool more readily than it naturallytwould, while the arms and rim are kept muffled in sand, and the synchronous cooling above referred to is at least approximated to a greater extent than if all parts were allowed to cool naturally.

11 It is often thought that large fillets are fine features of design in work of this sort, but many times they are highly detrimental to

good results. Where two walls meet and intersect, as in the shape of a *T*, if a large fillet is swept at the juncture, there will be a pool of liquid metal at this point which will remain liquid for a longer time than either wall because of its lessened facilities for quick cooling, and this pool of liquid metal is bound to act as a feeder, supplying metal for other parts, lower in the mold, that may shrink sooner, the result being, in practically every case, a void, or "draw," at the juncture point, bad enough in any case, but made worse by the presence of the large fillet. Of course there may be trouble from such intersections where no fillets at all are used, but the fillets should be kept small with the idea of allowing both walls and juncture to remain as nearly uniform in thickness as possible, and to have as nearly as may be the same capability for simultaneous shrinkage and solidification.

12 Among other classes of difficult castings I would place jacketed cylinders in the list of castings requiring careful consideration in design. In considering the case of a gas engine cylinder which is to be jacketed, the inner wall which resists the strain of explosion must be quite thick in order to afford the requisite strength against explosion pressures of ordinary nature and also against abnormal pressures due to pre-ignition and other causes. A cylinder of this sort, whose internal diameter might be 40 inches, could well have a thickness of cylinder wall amounting to 3 inches or more. The outer wall forming the jacket has only to stand the ordinary pressure of the cooling water, which might be quite low, often not exceeding 60 to 80 pounds per square inch, even where water is used direct from the city mains, and an outer jacket wall 1 inch thick might, on ordinary engineering assumptions, be regarded as ample to care for this pressure.

13 If the cylinder wall and the jacket wall are continuous, that is to say, if each extends rigidly from one end of the cylinder to the other, there is likely to be trouble when such a cylinder is cast or cooled, and even if it does not break at the start it is quite likely to break in service later because of the fact that a wall of metal 1 inch thick located out near the sides of the flask which act as cooling media, will not shrink in time with the inner wall whose thickness is three times as great and whose opportunity for radiation is quite inferior. It is reasonable to expect that the outer wall will cool first; will take on its final dimensions while the inner wall is still very hot; at a later period the inner wall will shrink to normal temperature and will find that its desire to contract is restricted by the compressive strength of the outer jacket wall, and the effect is a high degree of tension in the working cylinder wall. In such a case one good feature of design is to interrupt the jacket wall so that the inner

or working wall may have its own way and be unhampered in contracting; afterward it is closed up and rendered water tight by suitable mechanical means.

14 In such a case as that just cited, if the jacket wall must be cast continuous with the cylinder wall, it should not be designed solely in connection with its own theoretical stresses, but should be thickened up and made to approximate the working cylinder wall, so that it may cool down and contract more nearly simultaneously with the same, thus relieving the casting of stresses produced by asynchronous cooling. Such outer walls, and all such attachments to a large casting, as bosses, pads, and the like, should be designed not alone out of consideration to the working strains which will be applied to such bosses or pads, but the tendency of the iron to chill at such spots must be considered, and ofttimes the pads or the bosses require to be made several times as large as mere reasons of strength would dictate, to avoid a hardening and whitening of the iron in thin sections that would prevent its being machined to required dimensions.

15 After the foundryman has accepted the design and begun the work he may have several things to do in order to produce a reliable casting. If it is a cored casting he must guard against the cores being so strong that when confined within the contracting casting they will produce rupture of the metal. Among the usual means employed for producing a collapsible condition of core may be mentioned the use of saw-dust or coke or ashes, or a combination of them all, some of which ingredients will burn out as the casting cools and provide thereby for a collapse of the core. In other cases removable pieces, collapsible core arbors, straw wrapped core arbors and the like, tend to prevent castings from cracking because of an unyielding core.

16 In order to serve engineering purposes, castings should be not only apparently sound but really so. For this purpose risers and sink heads should often be employed on iron castings where they are not at present used. Steel foundry conditions compel such precautions to insure soundness, but in large iron foundry work interior cavities may exist without detection, and some of these may be avoided by the use of suitable feeding devices, risers and sink heads. If risers are not employed, the upper or cope side of the casting is likely not to be solid, because of the metal in the upper portions flowing or bleeding away from the interior of these sections to feed the shrinkage and the contraction in the lower portions of the casting. Gravitation is at work here as elsewhere, and as the sections of the casting that are lowest cool and pass from the liquid to the solid state, the diminished volume of the solidified iron produces demands

for fresh liquid metal from above to fill the voids, so that the upper portion of the casting is in such cases sacrificed for the benefit of the lower part. The top surface of such a casting may apparently be solid, but if drilled deeply, as for stud bolts or other purposes, it is likely that cavities and extreme openness of grain will be disclosed. In some such cases good can be accomplished by the use of local chills placed under the top flange, if a cylinder for instance which chills will *set* the metal in the flange before it has time to feed out of this region into any lower portion of the casting.

17 If specifications do not call for sink heads or risers, they may not be applied in the foundry, if the foundry has no interest in the design, and the resulting casting may be quite otherwise than as the engineering department had anticipated. The making and the cutting off of the sink head costs the foundryman heavily, and he may not be willing to spend the extra cost involved in the sink head method, and he may really not know whether the requirements are severe or otherwise.

18 In some large castings intrinsic strength per unit section may not be a serious requirement. The amount of metal provided for reasons of mass, or for other reasons, being so ample that the working strains per unit section are low and are easily complied with. In other cases the engineering design may require high quality of material because high working strains per unit section are to be imposed upon the finished casting. In such cases engineering attention should be paid to the size of the test specimen which is to furnish an index of quality, and to the relation which exists between the strength of cast iron when cast into light test pieces and that of the same metal when cast into heavy sections.

19 The writer has taken specimens from an iron casting having at one point in the casting tensile strength as high as 30 250 pounds per square inch, and as low as 20 502 per square inch in another and heavier section. The difference in this was wholly related to the thickness of the section and to the rate or speed of cooling, with its consequent effect upon the grain, and upon the strength of the iron of which the casting was composed. It might be said that large sections cannot be cast to yield the high strength that is sometimes associated in engineering minds with specimen test pieces cast in smaller sections of prevailing sizes.

20 It is well that the foundryman be acquainted to some extent with the engineering purposes for which these castings are intended. This knowledge will enable him to pay particular attention to such points or parts of the casting as are specially critical and to such as

are to be machine finished. He can usually arrange to place his chaplets, anchors and core vents so as to keep them clear of the working or sliding machined surfaces, and he can then better provide for producing a casting which is a clean one at these critical points. The molder, if left to himself, may and probably will, put chaplets and anchors directly in the path of a machined slide, unless someone who knows better sees him and prevents it. Sometimes this kind of information would seem to be obvious, but often it is not so, and a hollow cylindrical casting with flanges on each end, might, for all the molder knows, be a pipe having no special requirements, whereas it was intended to be a cylinder, which must be bored, faced and generally machined, and must be perfectly free from defects, and a casting in which chaplets and anchors are utterly inadmissible.

21 Certain points or spots on a large casting may require to be drilled and tapped and may demand a high quality at that spot. A suitably located chill will insure soundness and solidity here if the

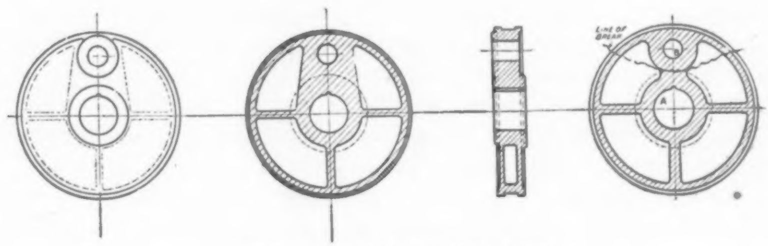


FIG. 1 CRANK ILLUSTRATION

foundryman knows what is demanded; if he does not know, the casting is made, looks good to him, is shipped out, and when machined is found to be hollow, cavitated or spongy at the critical spot.

22 In ordinary cases, designs for castings should be such that it will not be necessary for the foundryman to pay particular and extraordinary attention to special or heat treatment, because in the press of other matters, such treatment may occasionally be forgotten and omitted, or it may be imperfectly done by inexperienced men. A casting is best designed if it can be uncovered promptly after pouring, lifted out of its bed and deposited on the floor of the chipping shop. This is what is done with 95 per cent of the output of the average foundry, and it is what the workmen are accustomed to. Special cases soon become irksome and someone will perhaps assume the responsibility of saying: "This special treatment is all foolishness and the casting is just as good without it." There are, however,

cases in which it is necessary to design castings that do demand this special treatment.

23 Following is a sketch of a peculiar crank disc which was made in an iron foundry under the author's management some five or six years ago.

24 The first casting was poured in the usual and ordinary manner, and after a decent delay in the flask was uncovered and removed to the chipping shop. It lay on the floor of the latter department for a day or two after cleaning; it was then shipped to the machine shop, which is located about twelve miles away. When the casting arrived at the machine shop it was found that it had been so stressed by internal strains that a large piece had not only broken away from the balance of the casting, but it had jumped clear off the railway car on which it was being conveyed, and the missing piece was found by a track walker alongside of the railway track a few hours after its loss was reported. The line of breakage is indicated on the sketch, and the missing piece weighed perhaps 1½ to 2 tons. This case was studied carefully; the heavier interior member, being the last of the casting to cool, had set up the violent internal strains which caused the casting to rupture.

25 We arranged the next casting so that a few minutes after pouring had been done, a small stream of water in a regulated quantity was caused to drop into the hollow cores *A* and *B*, as shown on the sketch, compelling the hubs surrounding these cores to cool in advance of their natural time, and at least approximate synchronous cooling with the balance of the casting. The other portions of the casting during this period were kept muffled up in the sand and their cooling was delayed, while the cooling of the crank hubs was accelerated. After this method was adopted twelve such castings were made, all good, and they have been in service for some years.

COOLING TREATMENT FOR SPECIAL CASES

26 The writer had to produce a number of large cylinder heads for Corliss engines, these heads having ports for steam and exhaust valves formed in the heads. Structurally considered, these heads were like a cylindrical steam drum of large diameter but of very short length, having a flat head at each end, and were required to stand internal pressure.

27 Considering the resistance to internal pressure, the cylindrical shell or outer wall could be designed quite thin as the strains in it were all tensile strains, while the heads, being flat and of great area,

were subject to bending strains which demanded that these be greatly thickened up to make the flat surfaces, not easily stayed or braced together, strong enough to carry safely the pressure. In addition to this greater thickness of flat head, allowance had to be made for a machine finish on the flat surface, which was not required by the shell, and the disparity thus became still greater. The port openings for the admission and exhaust of steam, made large holes in this head or flat plate, which were to be tied across ports by bars or ribs. In cooling by natural processes these bars almost invariably cracked in the casting, because the cylindrical shell being thin, cooled first, and was assisted in doing so by its position which was very close to the sides of the flask, where radiation was active. The flat head, on the contrary, was at the bottom of the flask, where radiation was poorer, and it was practically twice as thick as the rim, and cooled more than twice as slowly. With these divergent tendencies in the casting trouble ensued. The rim cooled early and took on its final dimensions and in the form of a circle opposed to compression—the strongest possible shape. The head, or plate, or diaphragm, cooling later, had its contraction tendency resisted by the stiff rim and a struggle was set up. The tension member was of course the weaker and the large openings in the latter made the result a foregone conclusion—the diaphragm simply had to shrink or be stretched, the rim would not give—the ribs broke.

28 We cured this trouble by the following means: In the drag portion of the mold we placed a spiral coil of iron pipe through which we could circulate cooling water. This coil was placed as close to the face of the pattern as was considered safe, about 1½ inches away. The inner cores by which the head was hollowed out were also provided with similar interior cooling coils and the cope had a coil like that of the drag. After the casting was poured we waited for a few minutes to enable solidification to begin, and then we turned water into these cooling coils, and connecting the overflow to sewer connection, let the water run all night. The casting lay in the mold, the rim kept muffled in sand to delay cooling, while the coils close to the heads accelerated cooling. The result was most satisfactory and the castings produced by this process have stood the severest tests of several years continuous duty without failure. Heads of similar design made by other foundries cracked systematically, sometimes while the casting was still in the foundry, sometimes in the machine shop, but quite frequently not until after the engines were put into operation. In all cases the stress was there and the only question was, *when* would it cause breakage. See sketch below.

SHAPES

29 It might seem almost unnecessary to say that shapes of sections, flanges and other projections, should be so designed that the molder may most easily produce the desired shape without having

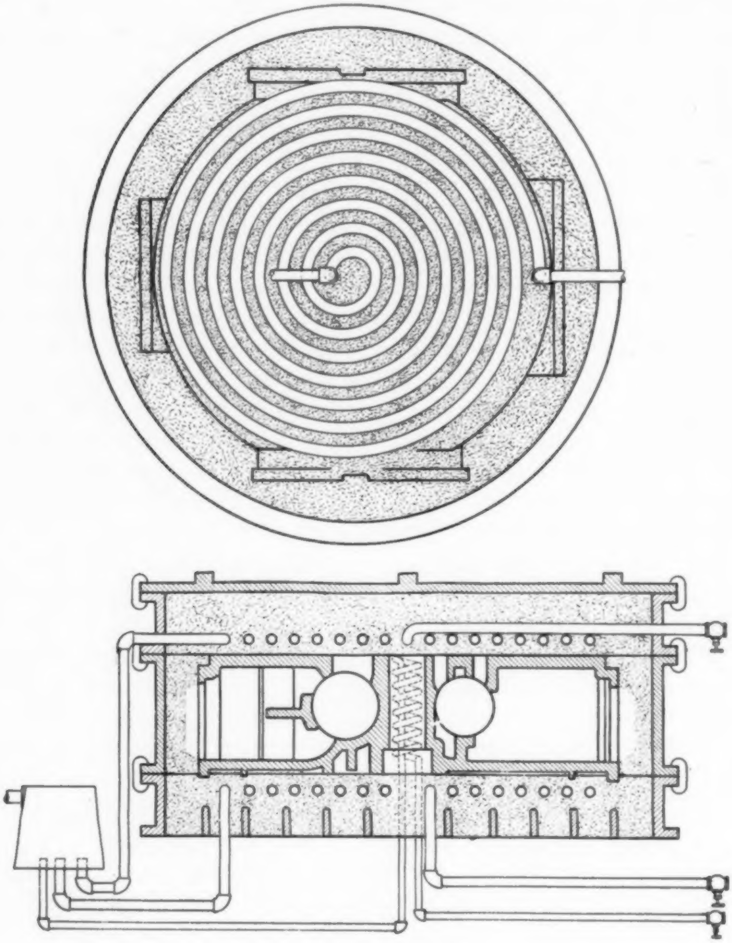


FIG. 2 CYLINDER HEAD

to use complicated means. If the designer or draftsman were a man who had a little practical experience in foundry work he would see numerous opportunities for making shapes that would "draw" easily, rather than certain other shapes that look well on paper but

are much harder to produce. Of course the foundryman can produce almost any conceivable shape if he has to, but engineering design is at its best when its shapes are at once suitable for the intended purpose and easily and cheaply produced. On work of considerable size a little more time required to deal with a detail may prevent doing any pouring today, with a strong probability that the molder can make that job last him "until tomorrow night." The designer

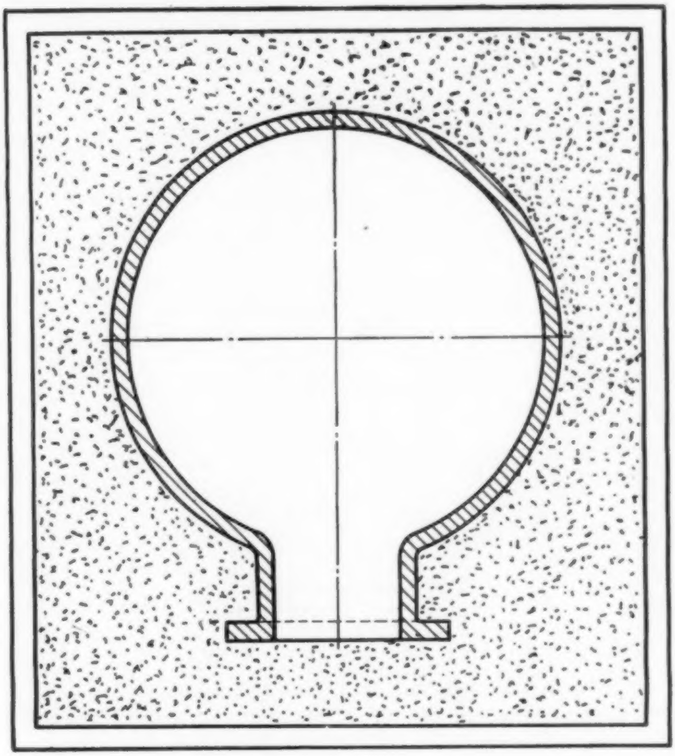


FIG. 3

should try to put himself in the molder's place and imagine himself making the mold in question. Then he will see what a small difference in design sometimes causes a big difference in cost and risk. An instance of this is Fig. 3 and represents a prospective nozzle with a flange for steam or water connection.

30 If the flange in Fig. 3 is at the bottom of a complicated casting it will require the flange pattern to be cut into removable sections

or a troublesome embedded core is required. If practicable to design as in Fig. 4, the neck draws naturally and the main core forms the flange. This sort of change may not always be possible, as certain designs will demand loose bolts, while Fig. 4 would call for stud bolts, but there are cases in which the foundry's troubles can be reduced in this manner.

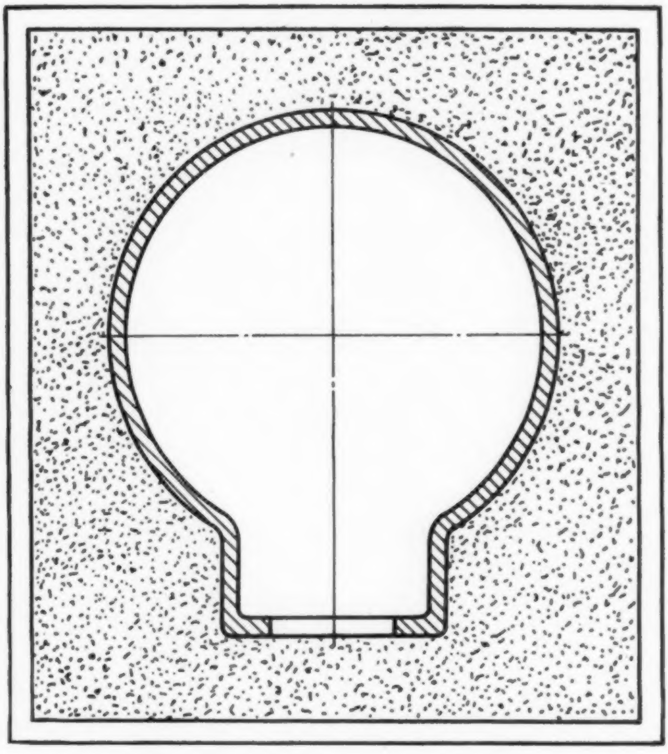


FIG. 4

31 It is not supposed that the foregoing is in any sense exhaustive, and it is presented with the idea chiefly of calling more attention than is usually given to the relation which exists between good design and good foundry practice, and to some of the physical phenomena connected with the manufacture of large and complicated shapes in iron castings.

32 Breakages are sometimes difficult to account for, and the designer may think the fault is with the quality of the iron which has

nothing at all to do with the trouble, and when the shape and design are the true cause. The "physics of the foundry" were not properly understood when the design was made.

33 If this paper can have the effect of making the designers of cast iron structures "sit up and take notice" of the foundry's physical problems—even a little bit, it will have accomplished the purpose of its author.

POWER TRANSMISSION BY FRICTION DRIVING

By W. F. M. GOSS, URBANA, ILL.
Member of the Society

A description of the application of friction wheels to ordinary forms of shaft driving, and an account of experiments made to determine the power capacity of such wheels when made of compressed straw fiber, was presented to the Society in December, 1896, under the caption of "Paper Friction Wheels." The facts herewith given are to be accepted as an extension of the earlier study.

A FRICTION DRIVE

2 A friction drive, as the term is here employed, consists of a fibrous or somewhat yielding driving wheel working in rolling contact with a metallic driven wheel. Such a drive may consist of a pair of plain cylindered wheels mounted upon parallel shafts, or of a pair of beveled wheels, or of any other arrangement which will serve in the transmission of motion by rolling contact. The use of such drives has steadily increased in recent years, with the result that the so called paper wheels have been improved in quality and a considerable number of new materials have been proposed for use in the construction of fibrous wheels.

THE WHEELS TESTED

3 Choosing materials which have been used for such purposes, driving wheels of each of the following materials have been tested:

To be presented at the New York Meeting (December 1907) of The American Society of Mechanical Engineers, and to form part of Volume 29 of the Transactions.

Straw fiber,
Straw fiber with belt dressing,
Leather fiber,
Leather,
Leather-faced iron,
Sulphite fiber,
Tarred fiber.

4 The straw fiber wheels are worked out of blocks which are built up usually of square sheets of straw board laid one upon another with a suitable cementing material between them and compacted under heavy hydraulic pressure. In the finished wheel, the sheets appear as discs, the edges of which form the face of the wheel. The material works well under a tool, but is harder and heavier than most woods and takes a good superficial polish. The wheel tested was taken from stock.

5 The wheel of straw fiber with belt dressing was similar to that of straw fiber, except that the individual sheets of straw board from which it was made had been treated, prior to their being converted into a block, with a "belt dressing," the composition of which is unknown to the writer.

6 The leather fiber wheel was made up of cemented layers of board, as were those already described, but in this case, the board, instead of being of straw fiber, was composed of ground sole leather cuttings, imported flax and a small percentage of wood pulp. The material is very dense and heavy.

7 The leather wheel was composed of layers or disks of sole leather.

8 The leather-faced iron wheel consisted of an iron wheel having a leather strip cemented to its face. After less than 300 revolutions, the bond holding the leather face failed and the leather separated itself from the metal of the wheel. This wheel proved entirely incapable of transmitting power and no tests of it are recorded.

9 The wheel of sulphite fiber was made up of sheets of board composed of wood pulp. The sulphite board is said to have been made on a steam-drying continuous-process machine in the same way as is the straw board.

10 The tarred fiber wheel was made up of board composed principally of tarred rope stock, imported French flax and a small percentage of ground sole leather cuttings.

11 Each of the fibrous driving wheels was tested in combination with driven wheels of the following materials:

Iron,
Aluminum,
Type metal.

All wheels tested, both driving and driven, were 16 inches in diameter. The face of all driving wheels was 1¾ inch, while that of all driven wheels was ½ inch.

12 The purpose of the experiments was to secure information which would permit rules to be formulated defining the power which may be transmitted by the various combinations of fibrous and metallic wheels already described. To accomplish this, it was necessary to determine for each combination of driving and driven wheel, the coefficient of friction under various conditions of operation; also the maximum pressures of contact which can be withstood by each of the fibrous wheels.

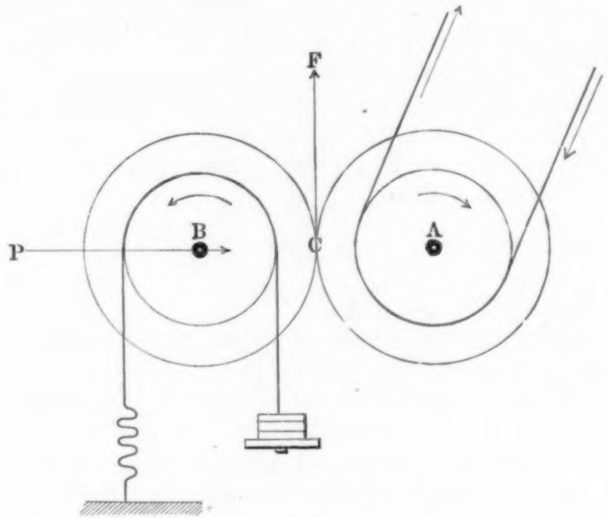


FIG. 1

13 The testing machine used is shown diagrammatically by Fig. 1. The principles involved will be made clear by assigning the functions of the actual machine to the several parts of this figure. The shaft *A* runs in fixed bearings, and carries the fibrous friction wheel. This wheel is the driver. Its shaft *A* carries, beside the friction wheel, two belt pulleys, one on either side, belts to which from any convenient source of power, serve to give motion to the driver. The shaft *B* carries the driven wheel which in every case was of metal. The bearings of this shaft are capable of receiving motion in a horizontal direction and by means of suitable mechanism connected therewith, the metal driven wheel may be made to press against the fibrous driver with any force desired. The pressure transmitted from *B* to *A*

is hereinafter referred to as the "pressure of contact," and is frequently represented by the symbol P. The tangential forces which are transmitted from the driver to the driven wheel are received, absorbed and measured by a friction brake upon the shaft B. In action, therefore, the driven wheel always works against a resistance, which resistance may be modified to any desired degree by varying the load upon the brake. The theory of the machine assumes that the energy absorbed by the brake equals that transmitted from the driver to the driven wheel at the contact point C. Accepting this assumption, the forces developed at the periphery of the brake wheel may readily be reduced to equivalent forces acting at the circumference of the driven wheel. This force, which is directly transmitted from the driver to the driven wheel, is hereinafter designated by the symbol F. It will be apparent from this description that the functions of the apparatus employed are such as will permit a study of the relationship existing between the contact pressure P and the resulting transmitted force F, which relation is most conveniently expressed as the coefficient of friction. It is,

$$f = \frac{F}{P}$$

It is obvious in comparing the work of two friction wheels, that the one which develops the highest coefficient of friction, other things being equal, can be depended upon to transmit the greatest amount of power.

14 The actual machine as used in the experiments is shown by Fig. 2. Its construction satisfies all conditions which have been defined except that shaft B, Fig. 1, does not run in bearings which are absolutely frictionless, as is required by a rigid adherence to the theoretical analysis already given. These bearings, however, are of the "standard roller bearing" type, and of ample size, and it is believed that the friction actually developed by them is so small compared with the energy transmitted between the wheels that it may be neglected.

15 The bearings of the fixed shaft A are secured to the frame of the machine. The bearings of the axle B are free to move horizontally in guides to which they are well fitted. These bearings are connected by links to the short arm of a bell-crank lever, the longer arm of which projects beyond the frame of the machine at the right hand end and carries the scale-pan and weights E. The effect of the weights is to bring the driven wheel in contact with the driver under a

predetermined pressure, the proportions of the bell-crank lever being such as to make this pressure in pounds equal,

$$P = 10\ W + 73$$

where W is the weight on the scale-pan E.

16 The fulcrum of the bell-crank lever is supported by a block G which may be adjusted horizontally by the hand wheel H at the rear of the machine, so that whatever may be the diameter of the driven wheel, the long arm of the bell-crank may be brought to a horizon-

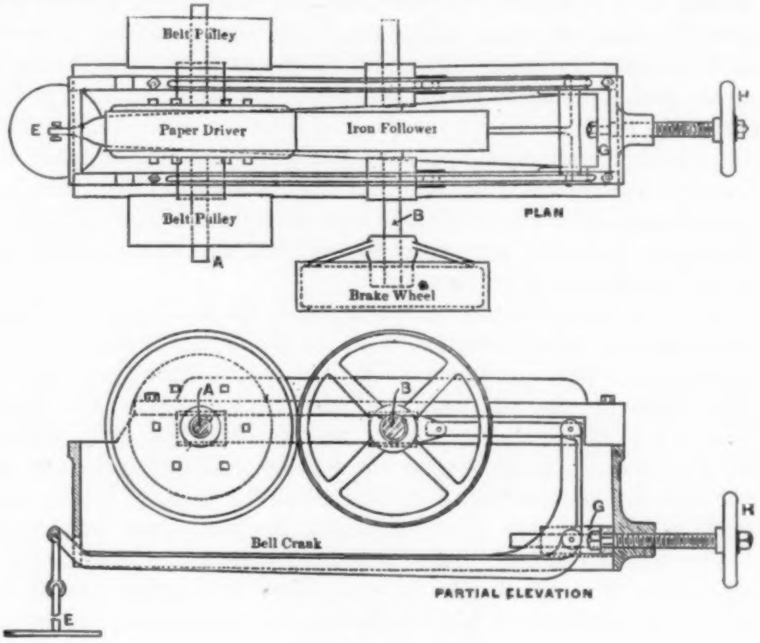


FIG. 2[a]

tal position. The constants employed in calculating the coefficient of friction from observed data are as follows:

Diameter of friction wheels (inches)	16
Effective diameter of brake (inches)	18.35
Ratio of diameter of friction wheel to that of brake wheel	1.145
Effective load on brake	F′
Coefficient of friction	$1.145\ \frac{F'}{P}$

The slippage between the friction wheels was determined from readings taken from the counters connected to each one of the shafts.

[a] Reproduced from Vol. 18, Transactions.

THE TESTS

17 In proceeding with a test, load was applied to the scale-pan *E*, Fig. 2, to give the desired pressure of contact, after which the hand-wheel *H*, at the back of the machine was employed to bring the bell-crank to its normal position. This accomplished, with the driving wheel in motion, the driven wheel would roll with it under the desired pressure of contact. A light load was next placed upon the brake to introduce some resistance to the motion of the driven shaft, and conditions thus obtained were continued constant for a considerable period. Readings were taken simultaneously from the counters, and time noted. After a considerable interval, the counters were again read, time again noted, and the test assumed to have ended. From the readings of the counters, and from the known diameters of the wheels in contact, the per cent of slip attending the action of the friction wheels was calculated. Three facts were thus made of record, namely: *a* The pressure of contact; *b* the coefficient of friction developed, and *c* the per cent of slip resulting from the development of said coefficient of friction.

18 This record having been completed, the load upon the brake was increased, and observations repeated, giving for the same pressure of contact, a new coefficient of friction and a higher percentage of slip. This process was continued until the slippage became excessive and in consequence thereof, the rotation of the driver ceased. By this process a series of tests was developed disclosing the relation between slip and coefficient of friction for the pressure in question. Such a series having been completed, the load upon the weight holder *E* was changed, giving a new pressure of contact, and the whole process repeated. As the work proceeded, curves showing the relation of coefficient of friction and slip for pressures per inch width of face in contact of 150 pounds and 400 pounds, respectively, were secured. The curves shown by Fig. 3 and Fig. 4 for the straw fiber driving wheel, in contact with the iron driven wheel are typical in their general form of those obtained from all combinations of wheels, but the curves of no two combinations were alike in their numerical values.

19 Having completed this series of tests at constant pressure, a series was next run for which the coefficient of slip was maintained constant at 2 per cent and the pressure of contact varied from values which were low to those which are judged to be near the maximum for service conditions, with results which in all cases were similar in character with those given for the straw fiber and iron wheels, as set

forth by Fig. 5. The numerical values of the points for other combinations were not the same as those shown by Fig. 5, but in the case of most of the combinations the coefficient of friction at constant slip gradually diminishes as the pressure of contact is increased. With this understanding of the general character of the results, the precise facts in each case are presented in numerical form rather than graphically. See Appendix. Table 1–8.

20 As the series of tests involving each combination of wheels proceeded, the increase in pressure of contact was discontinued when the markings made upon the driving wheel by the metallic follower became so distinct as to suggest that a safe limit had been reached,

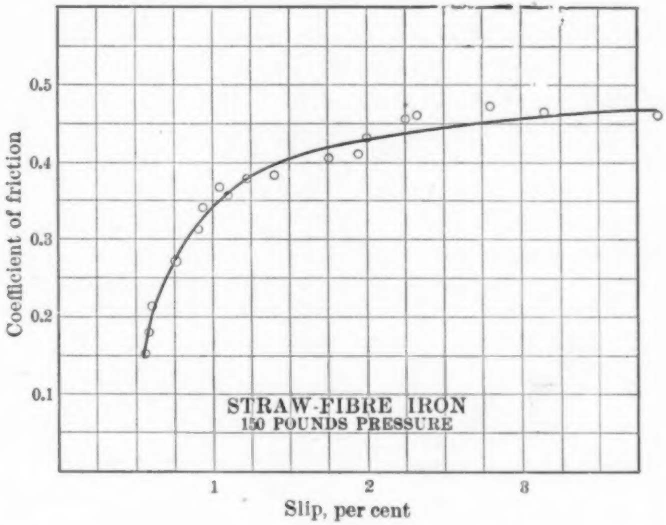


FIG. 3

but when all other data had been secured, tests were run for the purpose of determining the ultimate resistance of the fibrous wheel to crushing. The details of these will be described later.

Coefficient of Friction Developed by the Several Combinations of Wheels

STRAW FIBER AND IRON

21 The results of experiments involving a straw fiber driver, and an iron driven wheel are presented in the Appendix as Tests 1 to 36, Table 1. They are shown graphically in Fig. 3, 4 and 5. Fig. 4 and 5 illustrate the relation between slip and coefficient of friction when

the two wheels are working together under pressures per inch width of 150 and 400 pounds, respectively.

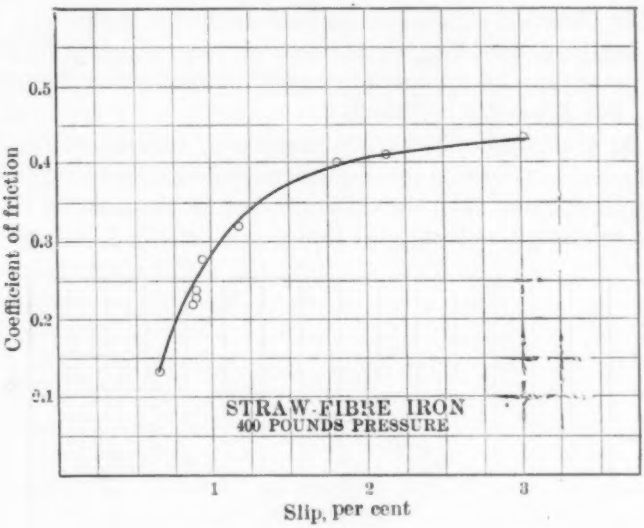


FIG. 4

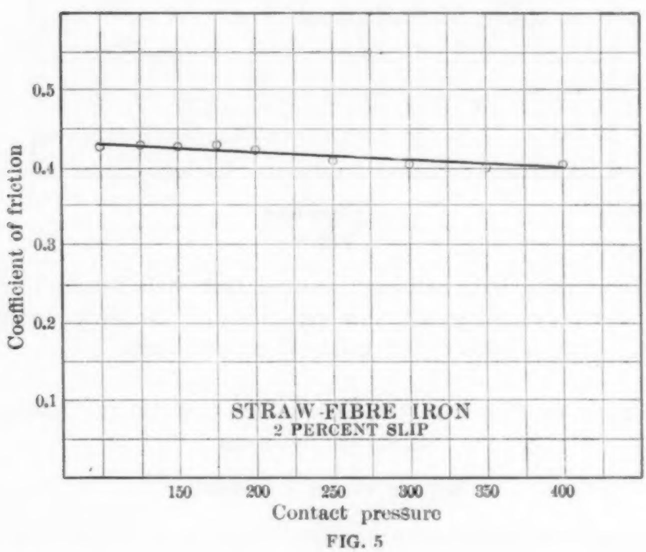


FIG. 5

22 The figures show that although the values of the coefficient of friction for 400 pounds pressure are slightly lower than corresponding

ones for 150 pounds pressures, the curves are sufficiently similar to establish the fact that the law governing change in coefficient of friction with slip is independent of the pressure of contact. When the slippage is 2 per cent, the coefficient of friction is 0.425 for a contact pressure of 150 pounds, and 0.410 for a contact pressure of 400 pounds. That the coefficients of friction for all pressures between the limits of 150 pounds and 400 pounds are practically constant is well shown by the diagram Fig. 5. The pressure of 400 pounds is the maximum at which tests of this combination of wheels were run, though straw fiber was successfully worked up to a pressure of 750 pounds.

STRAW FIBER AND ALUMINUM

23 The results of experiments involving a straw fiber driver and an aluminum driven wheel are given in the Appendix as Tests 37 to 60, Table 1. By curves plotted from values given, it can be shown that when the working pressure is 150 pounds per inch width and the slippage is 2 per cent, the coefficient of friction is 0.455; also, that for all pressures ranging from 100 to 400 pounds, the coefficient of friction is practically constant when the rate of slip is constant. The maximum pressure at which tests involving this combination of wheels were run was 400 pounds per inch width.

STRAW FIBER AND TYPE METAL

24 The results of experiments involving a straw fiber driver and a type metal driven wheel are presented in the Appendix as Tests 61 to 87, Table 1. By curves plotted from values given, it can be shown that when the two wheels are operated under a pressure of contact of 150 pounds per inch width and when the slip is 2 per cent, the coefficient of friction is 0.310; also, that for all pressures of contact ranging from 100 to 400 pounds, the coefficient of friction is practically constant when the slip is constant.

STRAW FIBER WITH BELT DRESSING AND IRON

25 The results of the experiments involving a straw fiber driver treated with belt dressing, and an iron driven wheel are presented in the Appendix as Tests 88 to 103, Table 2. Curves plotted from values given show that when the two wheels are worked together under a pressure of 150 pounds per inch width and when the slip is 2 per cent, the coefficient of friction is 0.12; also, that for all pressures up to 400 pounds per inch width, the coefficient of friction

remains constant. The greatest pressure at which tests of this combination of wheels were run was 500 pounds per inch width.

LEATHER FIBER AND IRON

26 The results of tests involving a leather fiber driver and an iron driven wheel are presented in the Appendix as Tests 104 to 127, Table 3. Curves plotted from these results show that when the two wheels are worked together under pressures of 150 pounds per inch in width and when the slip is 2 per cent, the coefficient of friction is 0.515. When the contact pressure is 300 pounds per inch width, the coefficient of friction is 0.510. The greatest pressure at which tests of this combination of wheels were run was 350 pounds per inch width, although leather fiber was successfully worked up to a pressure of 1200 pounds per inch width.

LEATHER FIBER AND ALUMINUM

27 The results of experiments involving a leather fiber driver and an aluminum driven wheel are presented in the Appendix as Tests 128 to 134, Table 3. Curves plotted from these results show that under a contact pressure of 150 pounds per inch width and a slip of 2 per cent, the coefficient of friction is 0.495. This value remains practically constant under all pressures. The maximum pressure used in tests of this combination of wheels was 400 pounds.

LEATHER FIBER AND TYPE METAL

28. The results of experiments involving a leather fiber driver and a type metal driven wheel are presented in the Appendix as Tests 135 to 146, Table 3. Curves plotted from these results show that when the wheels are operated under a contact pressure of 150 pounds per inch width and when the slip is 2 per cent, the coefficient of friction is 0.305; also, that with the slip constant, the coefficient of friction remains constant for all pressures up to 400 pounds per inch width.

TARRED FIBER AND IRON

29 The results of the experiments involving a tarred fiber driver and an iron driven wheel are presented in the Appendix as Tests 147 to 166 and 267 to 269, Table 4. Curves plotted from these results show that the change in the value of the coefficient of friction with change of slip is practically independent of the pressure of contact.

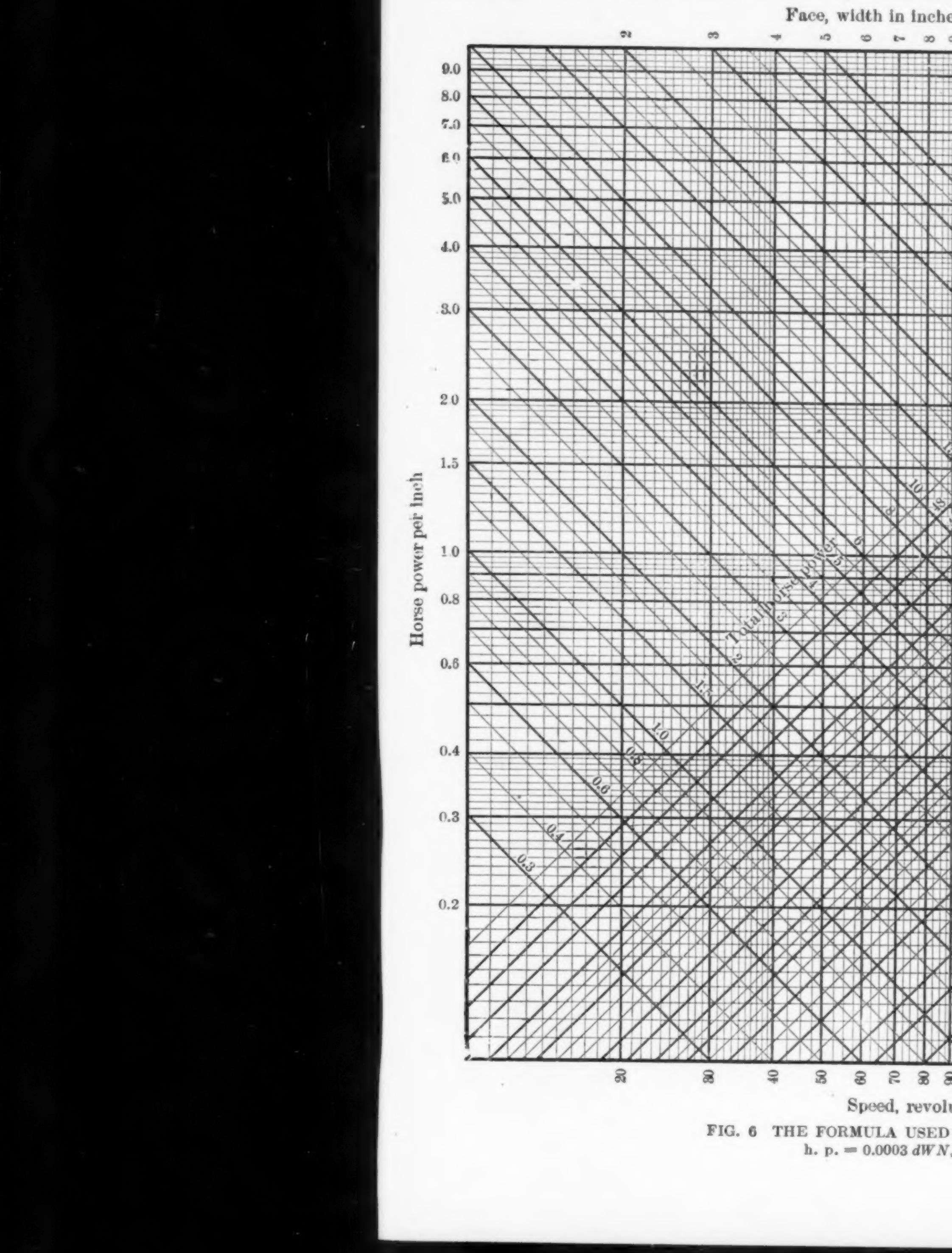
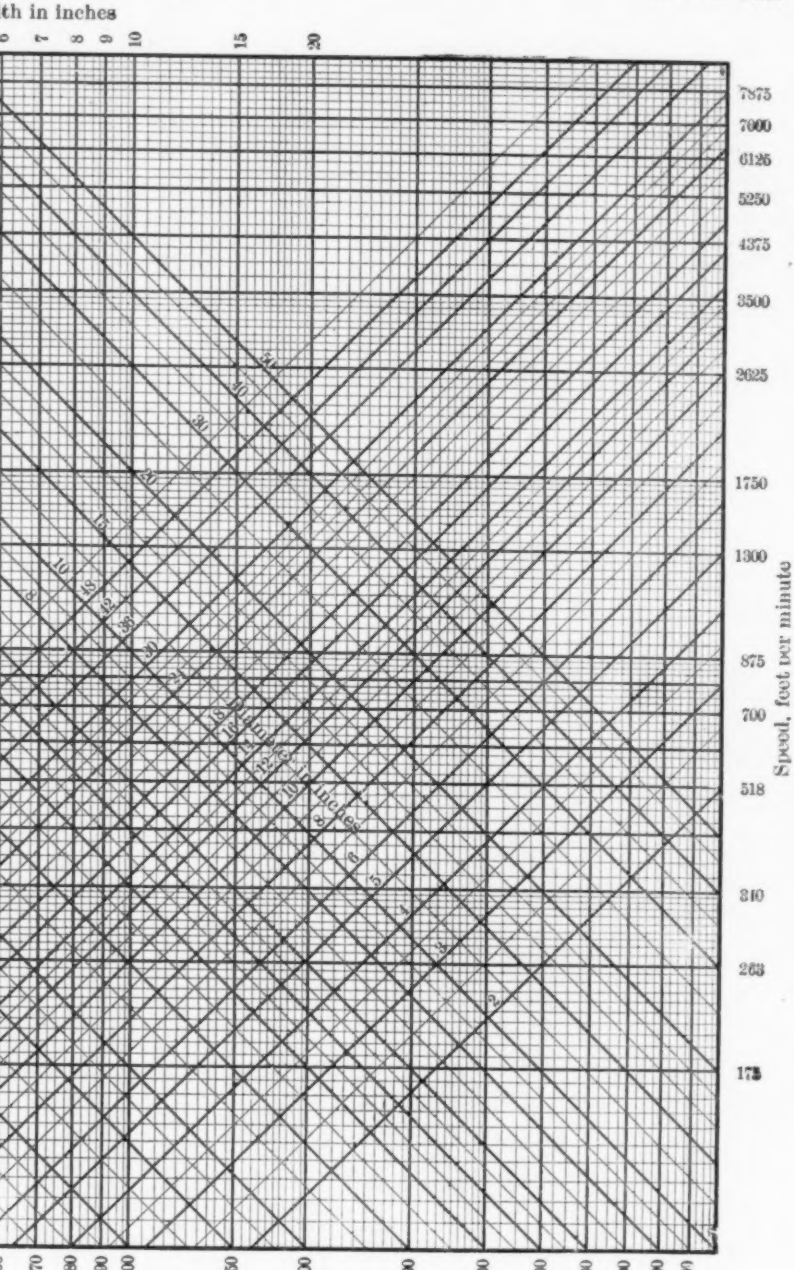


FIG. 6 THE FORMULA USED
$h.\ p. = 0.0003\, dWN,$



ULA USED IN CALCULATING THIS CHART IS
0.0003 dWN, where d = diameter
W = width
N = revolutions

When the slip is 2 per cent, the coefficient of friction is 0.220 for a pressure of contact of 150 pounds, and 0.250 for a pressure of contact of 400 pounds per inch width.

30 The fact that the data for this combination appear in two series results from the use of a duplicate tarred fiber driver. Tests of this combination were made also under different speeds when the wheels were working together under a pressure of contact of 250 pounds per inch width and when the slip was 2 per cent, with the result that the coefficient of friction was found to remain nearly constant for speeds of 450 and 3350 feet per minute, respectively. The greatest pressure at which tests of this combination of wheels were run was 400 pounds per inch width, although tarred fiber was successfully worked up to a pressure of 1200 pounds per inch width.

TARRED FIBER AND ALUMINUM

31 The results of experiments involving a tarred fiber driver and an aluminum driven wheel are presented in the Appendix as Tests 167 to 186, Table 4. Curves plotted from these results show that when the slip was 2 per cent and the pressure of contact 150 pounds per inch width, the coefficient of friction is 0.305; also, that for a pressure of 400 pounds per inch width, the coefficient of friction is 0.295. The greatest pressure at which tests of this combination were run was 400 pounds per inch width.

TARRED FIBER AND TYPE METAL

32 The results of experiments involving a tarred fiber driver and a type metal driven wheel are presented in the Appendix as Tests 187 to 202, Table 4. Curves plotted from these results show that when the slip is 2 per cent, the coefficient of friction developed under 150 pounds pressure per inch width is 0.275; and under 400 pounds pressure per inch width, the coefficient of friction is 0.270. The maximum pressure at which tests of this combination of wheels were run was 400 pounds per inch width.

LEATHER AND IRON

33 The results of experiments involving a leather driver and an iron driven wheel are presented in the Appendix as Tests 203 to 220, Table 5. Curves plotted from these results show that when the slip is 2 per cent, the coefficient of friction under a pressure of contact of 150 pounds per inch in width, is 0.225, and under a pressure of 400 pounds, 0.215. The maximum pressure at which tests of this com-

bination of wheels were run was 400 pounds per inch width, although the leather driver was successfully operated up to a pressure of 750 pounds per inch width.

LEATHER AND ALUMINUM

34 The results of experiments involving a leather driver and an aluminum driven wheel are presented in the Appendix as Tests 221 to 234, Table 5. Curves plotted from these results show that when the pressure is 150 pounds per inch in width, and the slip is 2 per cent, the coefficient of friction is 0.260, and when the pressure is 300 pounds per inch in width, the coefficient of friction is 0.295. The maximum pressure at which tests of this combination of wheels were made was 350 pounds per inch width.

LEATHER AND TYPE METAL

35 The results of the experiments involving a leather driver and a type metal driven wheel are presented in the Appendix as Tests 235 to 239, Table 5. Curves plotted from these results show that when the slip is 2 per cent and the contact pressure 150 pounds per inch width, the coefficient of friction developed is 0.410. The greatest pressure at which tests of this combination of wheels were run was 350 pounds per inch width.

SULPHITE FIBER AND IRON

36 The results of the experiments involving a sulphite fiber driver and an iron driven wheel are presented in the Appendix as Tests 240 to 245, Table 5. Curves plotted from these results show that when the slip is 2 per cent and the pressure 150 pounds per inch width, the coefficient of friction is 0.550. The maximum pressure at which tests of this combination of wheels were run was 350 pounds per inch width, although the sulphite fiber wheel was successfully operated up to a pressure of 700 pounds per inch width.

SULPHITE FIBER AND ALUMINUM

37 The results of the experiments involving a sulphite fiber driver and an aluminum wheel are presented in the Appendix as Tests 245 to 249, Table 5. Curves plotted from these values show that when the slip is 2 per cent and the pressure 150 pounds per inch width, the coefficient of friction developed is 0.410. The greatest pressure used in tests of this combination of wheels was 350 pounds per inch width.

SULPHITE FIBER AND TYPE METAL

38 The results of the experiments involving a sulphite fiber driver and a type metal driven wheel are presented in the Appendix as Tests 250 to 254, Table 6. Curves plotted from these results show that when the slip is 2 per cent and the contact pressure 150 pounds per inch width, the coefficient of friction is 0.515. The maximum pressure used in tests of this combination of wheels was 350 pounds per inch width.

RESISTANCE TO CRUSHING

39 Upon the completion of tests designed to disclose the frictional qualities of the several combinations, each fibrous wheel was subjected to test for the purpose of determining the maximum pressure per inch width of the face which could be sustained by it. This was accomplished by placing the wheel to be tested in the machine, under a pressure of contact of 200 pounds per inch width. The load on the brake was then adjusted to give a 2 per cent slip and this brake load was maintained without change throughout the remainder of the tests. Thus adjusted, the machine was operated until the driver had completed 15 000 revolutions. This accomplished, and for the purpose of determining the reduction, if any, in the diameter of the fibrous wheel, the brake load was removed and the operation of the machine continued without load for a period of 6000 revolutions, the readings of the counters being taken at the beginning and end of the period. Under conditions of no load, the actual slip was assumed to be zero and the apparent slip observed was used for determining the reduction in diameter of the fibrous wheel which had been brought about by the previous running under pressure. This accomplished, the pressure of contact was increased, usually by 100-pound increments, and the whole operation repeated. This process was continued until failure of the fibrous wheel resulted. It will be seen that the ultimate resistance to crushing, as found by the process described, is that pressure which could not be endured during 15 000 revolutions.

40 A summary of results is as follows:

STRAW FIBER

Load = 200 .... Decrease in diameter = 0.000
Load = 650 .... Decrease in diameter = 0.053
Load = 750 .... Decrease in diameter = 0.125

Note—The wheel failed before running 15 000 revolutions under 750 pounds pressure.

LEATHER FIBER

Load = 200	Decrease in diameter = 0.000
Load = 300	Decrease in diameter = 0.005
Load = 400	Decrease in diameter = 0.013
Load = 500	Decrease in diameter = 0.021
Load = 600	Decrease in diameter = 0.027
Load = 700	Decrease in diameter = 0.040
Load = 800	Decrease in diameter = 0.051
Load = 900	Decrease in diameter = 0.068
Load = 1000	Decrease in diameter = 0.099
Load = 1100	Decrease in diameter = 0.125
Load = 1200	Decrease in diameter = 0.200

Note—The wheel failed before running 15 000 revolutions under 1200 pounds pressure.

TARRED FIBER

Load = 200	Decrease in diameter = 0.000
Load = 300	Decrease in diameter = 0.026
Load = 400	Decrease in diameter = 0.038
Load = 500	Decrease in diameter = 0.052
Load = 600	Decrease in diameter = 0.071
Load = 700	Decrease in diameter = 0.098
Load = 800	Decrease in diameter = 0.138
Load = 900	Decrease in diameter = 0.182
Load = 1000	Decrease in diameter = 0.250
Load = 1100	Decrease in diameter = 0.295
Load = 1200	Decrease in diameter =

Note—The wheel failed before running 15 000 revolutions under 1200 pounds pressure.

LEATHER

Load = 350	Decrease in diameter = 0.047
Load = 450	Decrease in diameter = 0.090
Load = 550	Decrease in diameter = 0.150
Load = 650	Decrease in diameter = 0.240
Load = 750	Decrease in diameter =

Note—The wheel failed before running 15 000 revolutions under 750 pounds pressure.

SULPHITE FIBER

Load = 200	Decrease in diameter = 0.010
Load = 300	Decrease in diameter = 0.032
Load = 400	Decrease in diameter = 0.056
Load = 500	Decrease in diameter = 0.088
Load = 600	Decrease in diameter = 0.146
Load = 700	Decrease in diameter = 0.258

Note—The wheel failed before running 15 000 revolutions under 700 pounds pressure.

A CONCLUSION AS TO METAL WHEELS

41 An examination of Table 9, which presents a comparison of values representing the coefficient of friction of the several combinations of wheels tested, reveals the fact that the relative value of the

metal driven wheels is not the same when operated in combination with different fibrous driving wheels. It appears that those driving wheels which are the more dense, work more efficiently with the iron follower than with either the aluminum or type metal followers but in the case of the softer and less dense driving wheels, and especially in the case of those in which an oily substance is incorporated, driven wheels of aluminum and type metal are superior to those of iron. Finely powdered metal which is given off from the surface of the softer metal wheels seems to account for this effect and the character of the driving wheels is perhaps the only factor necessary to determine whether its presence will be beneficial or detrimental. Finally, with reference to the use of soft metal driven wheels, it should be noted that no combination of such wheels with a fibrous driver appears to have given high frictional results. Except when used under very light pressures, the wear of the type metal was too rapid to make a wheel of this material serviceable in practice.

CONCLUSIONS AS TO FIBROUS WHEELS

42 The relative value of the different fibrous wheels when employed as drivers in a friction drive may be judged by comparing their frictional qualities as set forth in Table 9 and their strength as set forth in paragraph 41. The results show at once that the addition of belt dressing to the composition of a straw fiber wheel is fatal to its frictional qualities. The highest frictional qualities are possessed by the sulphite fiber wheel which, on the other hand, is the weakest of all wheels tested. The leather fiber and tarred fiber are exceptionally strong and the former possesses frictional qualities of a superior order. The plain straw fiber which in a commercial sense is the most available of all materials dealt with, when worked upon an iron follower, possesses frictional qualities which are far superior to leather, and strength which is second only to the leather fiber and the tarred fiber.

THE POWER CAPACITY OF FRICTION GEARS

CONCERNING THE APPLICATION OF RESULTS

43 A review of the data discloses the fact that several of the friction wheels tested developed a coefficient of friction which in some cases exceeded 0.5. That is, such wheels rolling in contact have transmitted from driver to driven wheels a tangential force equal to 50 per cent of the force maintaining their contact. These wheels, also, were successfully worked under pressures of contact approaching

500 pounds per inch in width. Employing these facts as a basis from which to calculate power, it can readily be shown that a friction wheel a foot in diameter, if run at 1000 revolutions per minute, can be made to deliver in excess of 25 horse power for each inch in width. It is certainly true that any of the wheels tested may be employed to transmit for a limited time an amount of power which, when gaged by ordinary measures, seems to be enormously high, but obviously, performance under limiting conditions should not be made the basis from which to determine the commercial capacity of such devices. In view of this fact, it is important that there be drawn from the data such general conclusions with reference to pressures of contact, and frictional qualities as will constitute a safe guide to practice.

WORKING PRESSURE OF CONTACT

44 The results of these experiments do not furnish an absolute measure of the most satisfactory pressure of contact for service conditions. Other things being equal, the power transmitted will be proportional to this pressure and hence it is desirable that the value be made as high as practicable. On the other hand, it has been noted as one of the observations of the test that as higher pressures are used, there appears to be a gradual yielding of the structure of the fibrous wheels, and it is reasonable to conclude that the life of a given wheel will in a large measure depend upon the pressure under which it is required to work. After a careful study of the facts involved, it has been determined to base an estimate of the power which may be transmitted upon a pressure of contact which is 20 per cent of the ultimate resistance of the material as established by the crushing tests already described. This basis gives the following results:

SAFE WORKING PRESSURES OF CONTACT

Straw fiber	pressure = 150
Leather fiber	pressure = 240
Tarred fiber	pressure = 240
Sulphite fiber	pressure = 140
Leather	pressure = 150

COEFFICIENT OF FRICTION

45 The coefficient of friction for all wheels tested approaches its maximum value when the slip between driver and driven wheel amounts to 2 per cent and, within narrow limits, its value is practically independent of the pressure of contact. A summary of maximum results is shown by Table 9. In view of these facts, it is pro-

posed to base a measure of the power which may be transmitted by such friction wheels as those tested upon the frictional qualities developed at a pressure of 150 pounds per inch of width, when operating under a load causing 2 per cent slip. For safe operation, however, deductions must be made from the observed values. Thus, the results of the experiments disclose the power transmitted from wheel to wheel, while in the ordinary application of friction drives some power will be absorbed by the journals of the driven axle so that the amount of power which can be taken from the driven shaft will be somewhat less than that transmitted to the wheel on said shaft. Again, under the conditions of the laboratory, every precaution was taken to keep the surfaces in contact free of all foreign matter. It was, for example, observed that the accumulation of laboratory dust upon the surfaces of the wheels had a temporary effect upon the frictional qualities of the wheels, and friction wheels in service are not likely to be as carefully protected as were those in the laboratory. In view of these facts, it has been thought proper to use as the basis from which to determine the amount of power which may be transmitted by such wheels as those tested, a coefficient of friction which shall be 60 per cent of that developed under the conditions of the laboratory. This basis gives the following results:

COEFFICIENT OF FRICTION—WORKING VALUES

Straw fiber and iron	coefficient of friction = 0.255
Straw fiber and aluminum	coefficient of friction = 0.273
Straw fiber and type metal	coefficient of friction = 0.186
Leather fiber and iron	coefficient of friction = 0.309
Leather fiber and aluminum	coefficient of friction = 0.297
Leather fiber and type metal	coefficient of friction = 0.183
Tarred fiber and iron	coefficient of friction = 0.150
Tarred fiber and aluminum	coefficient of friction = 0.183
Tarred fiber and type metal	coefficient of friction = 0.165
Sulphite fiber and iron	coefficient of friction = 0.330
Sulphite fiber and aluminum	coefficient of friction = 0.318
Sulphite fiber and type metal	coefficient of friction = 0.309
Leather and iron	coefficient of friction = 0.135
Leather and aluminum	coefficient of friction = 0.216
Leather and type metal	coefficient of friction = 0.246

HORSE POWER

46 Having now determined a safe working pressure of contact and a representative value for the coefficient of friction, it is possible to formulate equations expressing the horse power which may be transmitted by each combination of wheels tested. Thus, calling d the

diameter of the friction wheel in inches, W the width of its face in inches and N the number of revolutions per minute, the equations become, for combinations of,

Straw fiber and iron	h.p. = $0.00030\ dWN$
Straw fiber and aluminum	h.p. = $0.00033\ dWN$
Straw fiber and type metal	h.p. = $0.00022\ dWN$
Leather fiber and iron	h.p. = $0.00059\ dWN$
Leather fiber and aluminum	h.p. = $0.00057\ dWN$
Leather fiber and type metal	h.p. = $0.00035\ dWN$
Tarred fiber and iron	h.p. = $0.00029\ dWN$
Tarred fiber and aluminum	h.p. = $0.00035\ dWN$
Tarred fiber and type metal	h.p. = $0.00031\ dWN$
Sulphite fiber and iron	h.p. = $0.00037\ dWN$
Sulphite fiber and aluminum	h.p. = $0.00035\ dWN$
Sulphite fiber and type metal	h.p. = $0.00034\ dWN$
Leather and iron	h.p. = $0.00016\ dWN$
Leather and aluminum	h.p. = $0.00026\ dWN$
Leather and type metal	h.p. = $0.00029\ dWN$

47 By use of the first of these formulae, values have been calculated showing the horse power which may be transmitted by a straw fiber driver of one inch width of face in contact with an iron driven wheel. These values are presented as Table 10 accompanying. They include diameters which range from 3 to 53 inches and speeds of revolutions ranging from 100 to 2000. While the values of this table apply only to a combination of straw fiber and iron, it is possible by the use of a mutiplier to secure from them values which correspond to other combinations. Such a list of mutipliers is given below:

MULTIPLIERS

Straw fiber and aluminum	= 1.10
Straw fiber and type metal	= 0.73
Leather fiber and iron	= 1.97
Leather fiber and aluminum	= 1.90
Leather fiber and type metal	= 1.17
Tarred fiber and iron	= 0.97
Tarred fiber and aluminum	= 1.17
Tarred fiber and type metal	= 1.03
Sulphite fiber and iron	= 1.23
Sulphite fiber and aluminum	= 1.17
Sulphite fiber and type metal	= 1.13
Leather and iron	= 0.53
Leather and aluminum	= 0.87
Leather and type metal	= 0.97

48 For example, to determine the amount of power which can be transmitted by a given friction wheel of sulphite fiber working upon an iron driven wheel, values which are given in Table 10 should be

TABLE 10

HORSE POWER TRANSMITTED PER INCH OF WIDTH BY

Diameter of Wheel	REVOLUTIONS PER M																				
	100	120	140	160	180	200	220	240	260	280	300	325	350	375	400	425	450	475	500	550	600
3	0.09	0.11	0.13	0.14	0.16	0.18	0.20	0.22	0.23	0.25	0.27	0.29	0.32	0.34	0.36	0.38	0.41	0.43	0.45	0.50	0.5
4	0.12	0.14	0.17	0.19	0.22	0.24	0.26	0.29	0.31	0.24	0.36	0.39	0.42	0.45	0.48	0.51	0.54	0.57	0.60	0.66	0.7
5	0.15	0.18	0.21	0.24	0.27	0.30	0.33	0.36	0.39	0.42	0.45	0.49	0.53	0.56	0.60	0.64	0.68	0.71	0.75	0.83	0.9
6	0.18	0.22	0.25	0.29	0.32	0.36	0.40	0.43	0.47	0.50	0.54	0.59	0.63	0.68	0.72	0.77	0.81	0.86	0.90	0.99	1.0
7	0.21	0.25	0.29	0.34	0.38	0.42	0.46	0.50	0.55	0.59	0.63	0.68	0.74	0.79	0.84	0.89	0.95	1.00	1.05	1.16	1.2
8	0.24	0.29	0.34	0.38	0.43	0.48	0.53	0.58	0.62	0.67	0.72	0.78	0.84	0.90	0.96	1.02	1.08	1.14	1.20	1.32	1.4
9	0.27	0.32	0.38	0.43	0.49	0.54	0.59	0.65	0.70	0.76	0.81	0.88	0.95	1.01	1.08	1.15	1.22	1.28	1.35	1.49	1.6
10	0.30	0.36	0.42	0.48	0.54	0.60	0.66	0.72	0.78	0.84	0.90	0.98	1.05	1.13	1.20	1.28	1.35	1.43	1.50	1.65	1.8
11	0.33	0.40	0.46	0.53	0.59	0.66	0.73	0.79	0.86	0.92	0.99	1.07	1.16	1.24	1.32	1.40	1.49	1.57	1.65	1.82	1.9
12	0.36	0.43	0.50	0.58	0.65	0.72	0.79	0.86	0.94	1.01	1.08	1.17	1.26	1.35	1.44	1.53	1.62	1.71	1.80	1.98	2.1
13	0.39	0.47	0.55	0.62	0.70	0.78	0.86	0.94	1.01	1.09	1.17	1.27	1.37	1.46	1.56	1.66	1.76	1.85	1.95	2.15	2.3
14	0.42	0.50	0.59	0.67	0.76	0.84	0.92	1.01	1.09	1.18	1.26	1.37	1.47	1.58	1.68	1.79	1.89	2.00	2.10	2.31	2.5
15	0.45	0.54	0.63	0.72	0.81	0.90	0.99	1.08	1.17	1.26	1.35	1.46	1.58	1.69	1.80	1.91	2.03	2.14	2.25	2.98	2.7
16	0.48	0.58	0.67	0.77	0.86	0.96	1.06	1.15	1.25	1.34	1.44	1.56	1.68	1.80	1.92	2.04	2.16	2.28	2.40	2.64	2.8
17	0.51	0.61	0.61	0.82	0.92	1.02	1.12	1.22	1.33	1.43	1.53	1.66	1.79	1.91	2.04	2.17	2.30	2.42	2.55	2.81	3.0
18	0.54	0.65	0.66	0.86	0.97	1.08	1.19	1.30	1.40	1.51	1.62	1.76	1.89	2.03	2.16	2.30	2.43	2.57	2.70	2.97	3.2
19	0.57	0.68	0.70	0.91	1.03	1.14	1.25	1.37	1.48	1.60	1.71	1.85	2.00	2.14	2.28	2.42	2.57	2.71	2.85	3.14	3.4
20	0.60	0.72	0.74	0.96	1.08	1.20	1.32	1.44	1.56	1.68	1.80	1.95	2.10	2.25	2.40	2.55	2.70	2.85	3.00	3.30	3.6
21	0.63	0.76	0.78	1.01	1.13	1.26	1.39	1.51	1.64	1.76	1.89	2.05	2.21	2.36	2.52	2.68	2.84	2.99	3.15	3.47	3.7
22	0.66	0.79	0.82	1.06	1.19	1.32	1.45	1.58	1.72	1.85	1.98	2.15	2.31	2.48	2.64	2.81	2.97	3.14	3.30	3.63	3.9
23	0.69	0.83	0.87	1.10	1.24	1.38	1.52	1.66	1.79	1.93	2.07	2.24	2.42	2.59	2.76	2.93	3.11	3.28	3.45	3.80	4.1
24	0.72	0.86	0.91	1.13	1.30	1.44	1.58	1.73	1.87	2.02	2.16	2.34	2.52	2.70	2.88	3.06	3.24	3.42	3.60	3.96	4.3
25	0.75	0.90	0.95	1.20	1.35	1.50	1.65	1.80	1.95	2.10	2.25	2.44	2.63	2.81	3.00	3.19	3.38	3.56	3.75	4.13	4.5
26	0.78	0.94	0.99	1.25	1.40	1.56	1.72	1.87	2.03	2.18	2.34	2.54	2.73	3.93	3.12	3.32	3.51	3.71	3.90	4.29	4.6
27	0.81	0.97	1.03	1.30	1.46	1.62	1.78	1.95	2.11	2.27	2.43	2.63	2.84	3.04	3.24	3.44	3.65	3.85	4.05	4.46	4.8
28	0.84	1.01	1.08	1.34	1.51	1.68	1.85	2.02	2.18	2.35	2.52	2.73	2.94	3.13	3.36	3.57	3.78	3.99	4.20	4.62	5.0
29	0.87	1.04	1.12	1.39	1.57	1.74	1.91	2.09	2.26	2.44	2.61	2.83	3.05	3.26	3.48	3.70	3.92	4.13	4.35	4.79	5.2
30	0.90	1.08	1.16	1.44	1.62	1.80	1.98	2.16	2.34	2.52	2.10	2.93	3.15	3.38	3.60	3.83	4.05	4.28	4.50	4.95	5.4
31	0.93	1.12	1.20	1.49	1.67	1.86	2.05	2.23	2.42	2.60	2.79	3.02	2.26	3.49	3.72	3.95	4.19	4.42	4.65	5.12	5.5
32	0.96	1.15	1.24	1.54	1.73	1.92	2.11	2.31	2.50	2.69	2.88	3.12	2.36	3.60	3.84	4.08	4.32	4.56	4.80	5.28	5.7
33	0.99	1.19	1.29	1.58	1.78	1.98	2.18	2.38	2.57	2.77	2.97	3.22	2.47	3.71	3.96	4.21	4.46	4.70	4.95	5.45	5.9
34	1.02	1.22	1.33	1.63	1.84	2.04	2.24	2.45	2.65	2.86	3.06	3.32	2.57	3.83	4.08	4.34	4.59	4.85	5.10	5.61	6.1
35	1.05	1.26	1.37	1.68	1.89	2.10	2.31	2.52	2.73	2.94	3.15	3.41	2.68	3.94	4.20	4.46	4.73	4.99	5.25	5.78	6.3
36	1.08	1.30	1.41	1.73	1.94	2.16	2.38	2.59	2.81	3.02	3.24	3.51	2.78	4.05	4.32	4.59	4.86	5.13	5.40	5.94	6.4
37	1.11	1.33	1.45	1.78	2.00	2.22	2.44	2.67	2.89	3.11	3.33	3.61	2.89	4.16	4.44	4.72	5.00	5.27	5.55	6.11	6.6
38	1.14	1.37	1.50	1.82	2.05	2.28	2.51	2.74	2.96	3.19	3.42	3.71	2.99	4.28	4.56	4.85	5.13	5.42	5.70	6.27	6.8
39	1.17	1.40	1.54	1.87	2.11	2.34	2.57	2.81	3.04	3.28	3.51	3.80	4.10	4.39	4.68	4.97	5.37	5.56	5.85	6.44	
40	1.20	1.44	1.58	1.92	2.16	2.40	2.64	2.88	3.12	3.36	3.60	3.90	4.20	4.50	4.80	5.10	5.40	5.70	6.00	6.60	
41	1.23	1.48	1.62	1.97	2.21	2.46	2.71	2.95	3.20	3.44	3.69	4.00	4.31	4.61	4.92	2.23	5.54	5.84	6.15	6.77	
42	1.26	1.51	1.66	2.02	2.27	2.52	2.77	3.03	3.28	3.53	3.78	4.10	4.41	4.73	5.04	5.36	5.67	5.99	6.30		
43	1.29	1.55	1.71	2.06	2.32	2.58	2.84	3.10	3.35	3.61	3.87	4.19	4.52	4.84	5.16	5.48	5.80	6.13	6.45		
44	1.32	1.58	1.75	2.11	2.38	2.64	2.90	3.17	3.43	3.70	3.96	4.29	4.62	4.95	5.28	5.61	5.94	6.27	6.60		
45	1.35	1.62	1.79	2.16	2.43	2.70	2.97	3.24	3.51	3.78	4.05	4.39	4.73	5.06	5.40	5.74	6.08	6.41	6.75		
46	1.32	1.66	1.83	2.21	2.48	2.76	3.04	3.31	3.59	3.86	4.14	4.49	4.83	5.18	5.52	5.87	6.21	6.56	6.90		
47	1.41	1.69	1.87	2.26	2.54	2.82	3.10	3.39	3.67	3.95	4.23	4.58	4.94	5.29	5.64	5.99	3.45	6.70			
48	1.44	1.73	1.91	2.30	2.59	2.88	3.17	3.46	3.74	4.03	4.32	4.68	5.04	5.40	5.76	6.12	6.48	6.84			
49	1.47	1.76	1.96	2.35	2.65	2.94	3.23	3.53	3.82	4.12	4.41	4.78	5.15	5.51	5.88	6.25	6.62				
50	1.50	1.80	2.00	2.40	2.70	3.00	3.30	3.60	3.90	4.20	4.50	4.88	5.25	5.63	6.00	6.38	6.75				

The formula used in calculating this table is

h. p. $= 0.0003\ dWN$

Where d = diameter of wheel

W = width of face

N = revolutions per minute.

ABLE 10

OF WIDTH BY STRAW FIBER FRICTION WHEELS

UTIONS PER MINUTE

	550	600	650	700	750	800	850	900	950	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
5	0.50	0.54	0.59	0.63	0.68	0.72	0.77	0.81	0.86	0.90	0.99	1.08	1.17	1.26	1.35	1.44	1.53	1.62	1.71	1.80
0	0.66	0.72	0.78	0.84	0.90	0.96	1.02	1.08	1.14	1.20	1.32	1.44	1.56	1.68	1.80	1.92	2.04	2.16	2.28	2.40
5	0.83	0.90	0.98	1.05	1.13	1.20	1.28	1.35	1.43	1.50	1.65	1.80	1.95	2.10	2.25	2.40	2.55	2.70	2.85	3.00
0	0.99	1.08	1.17	1.26	1.35	1.44	1.53	1.62	1.71	1.80	1.98	2.16	2.34	2.52	2.70	2.88	3.06	3.24	3.42	3.60
5	1.16	1.26	1.37	1.47	1.58	1.68	1.79	1.89	2.00	2.10	2.31	2.52	2.73	2.94	3.15	3.36	3.57	3.78	3.99	4.20
0	1.32	1.44	1.56	1.68	1.80	1.92	2.04	2.16	2.28	2.40	2.64	2.88	3.12	3.36	3.60	3.84	4.08	4.32	4.56	4.80
5	1.49	1.62	1.76	1.89	2.03	2.16	2.30	2.43	2.57	2.70	2.97	3.24	3.51	3.78	4.05	4.32	4.59	4.86	5.13	5.40
0	1.65	1.80	1.95	2.10	2.25	2.40	2.55	2.70	2.85	3.00	3.30	3.60	3.90	4.20	4.50	4.80	5.10	5.40	5.70	6.00
5	1.82	1.98	2.15	2.31	2.48	2.64	2.81	2.97	3.14	3.30	3.63	3.96	4.29	4.64	4.95	5.28	5.61	5.94	6.27	
0	1.98	2.16	2.34	2.52	2.70	2.88	3.06	3.24	3.42	3.60	3.96	4.32	4.68	5.04	5.40	5.76	6.12	6.48		
5	2.15	2.34	2.54	2.73	2.93	3.12	3.32	3.57	3.71	3.90	4.79	4.68	5.07	5.46	5.85	6.24	6.63			
0	2.31	2.52	2.73	2.94	3.15	3.36	3.57	3.78	3.99	4.20	4.62	5.04	5.46	5.88	6.30	6.72				
5	2.98	2.70	2.93	3.15	3.38	3.60	3.83	4.05	4.28	4.50	4.95	5.40	5.85	6.30	6.75					
0	2.64	2.88	3.12	3.36	3.60	3.84	4.08	4.32	4.56	4.80	5.28	5.76	6.24	6.72						
5	2.81	3.06	3.32	3.57	3.83	4.08	4.34	4.59	4.85	5.10	5.61	6.12	6.63							
0	2.97	3.24	3.51	3.78	4.05	4.32	4.59	4.86	5.13	5.40	5.94	6.48								
5	3.14	3.42	3.71	3.99	4.28	4.56	4.85	5.13	5.42	5.70	6.27	6.84								
0	3.30	3.60	3.90	4.20	4.50	4.80	5.10	5.40	5.70	6.00	6.60									
5	3.47	3.78	4.10	4.41	4.73	5.04	5.36	5.67	5.99	6.30	6.93									
0	3.63	3.96	4.29	4.62	4.95	5.28	5.61	5.94	6.27	6.60										
5	3.80	4.14	4.49	4.83	5.18	5.52	5.87	6.21	6.56											
0	3.96	4.32	4.68	5.04	5.40	5.76	6.12	6.48	6.84											
5	4.13	4.50	4.88	5.25	5.63	6.00	6.38	6.75												
0	4.29	4.68	5.07	5.46	5.85	6.24	6.53													
5	4.46	4.86	5.27	5.67	6.08	6.48	6.89													
0	4.62	5.04	5.46	5.88	6.30	6.72														
5	4.79	5.22	5.66	6.09	6.53															
0	4.95	5.40	5.85	6.30	6.75															
5	5.12	5.58	6.05	6.51																
0	5.28	5.76	6.24	6.72																
5	5.45	5.94	6.44																	
0	5.61	6.12	6.63																	
5	5.78	6.30	6.83																	
0	5.94	6.48																		
5	6.11	6.66																		
0	6.27	6.84																		
5	6.44																			
0	6.60																			
5	6.77																			
0																				
5																				
0																				
75																				
0																				

To determine the power which may be transmitted by friction wheels of sulphite fiber, leather fiber, leather, and tarred fiber the values of this table should be multiplied by the following constants:

Sulphite fiber,	1.23
Leather fiber,	1.97
Leather,	0.53
Tarred fiber,	0.97

multiplied by 1.2. Such of these multipliers as are likely to be most used are presented with the table.

49 A more flexible means of approach to the general problem involved by the use of fibrous friction wheels than that which is supplied by Table 10 is supplied by Fig. 36. This chart gives a convenient means of determining the value of any one of the variable factors in the formula h. p. = 0.0003 dWN for the straw fiber friction wheel working in combination with an iron follower, the remaining factors being known or assumed. To transform values thus found to corresponding ones for the other possible combinations of wheels, it is only necessary to multiply by the proper factor chosen from the table of multipliers given in the preceding paragraph. The use of the chart may be illustrated as follows:

a *To find surface speed,* locate the intersection of the vertical line representing the given speed in revolutions per minute with the diagonal one representing the given diameter. The horizontal line passing through this point will give the surface speed in feet per minute on the vertical scale to the right of the diagram.

b *To find the horse power for a given wheel,* locate the intersection of the vertical line representing the given speed in revolutions per minute with the diagonal line representing the given diameter. Follow the horizontal line passing through this point to the right or left until the intersection between it and the vertical line representing the given width, as shown on the scale at the top of the diagram, is reached The diagonal line passing through this point marked "Total horse power" will represent the required horse power.

c *To find the face width of a given wheel* necessary to transmit a given horse power, the speed being known, locate the intersection of the vertical line representing the given speed in revolutions per minute with the diagonal line representing the given diameter. Follow the horizontal line passing through this point to the right or left until the intersection between it and the diagonal line representing the required horse power is reached. The vertical line passing through this point will give the width of face in inches on the scale at the top of the diagram.

Application of Results to Forms Other than Those Experimented Upon

FACE FRICTION GEARING

50 A fibrous driving wheel, acting upon the face of a metal disc, constitutes a form of friction gear which is serviceable for a variety of purposes. If the driver is so mounted that it may be moved across the face of the disc, the velocity ratio may be varied, and the direction of the disc's motion may be reversed. The contact is not one of pure rolling. If the driver is cylindrical in form, the action along its line of contact with the disc is attended by slip, the amount of which changes for every different point along the line. The recognition of this fact is essential to a discussion of the power transmitting capacity of the device.

51 Experiments involving the spur form of friction wheels already described have shown that slip greatly affects the coefficient of friction; that the coefficient approaches its maximum value when the slip reaches 2 per cent, and that when the slip exceeds 3 per cent, the coefficient diminishes. It is known that reductions in the value of the coefficient with increments of slip beyond 3 per cent are at first gradual, although the characteristics of the testing machine have not permitted a definition of this relation for slip greater than 4 per cent. The experiments, however, fully justify the statement that for maximum results, the slippage should not be less than 2 per cent nor more than 4 per cent. It is the maximum limit with which we are concerned in considering the amount of power which may be transmitted by face friction gearing.

52 From the discussion of the previous paragraph, it should be evident that, for best results, the width of face of the friction driver, and the distance between the driver and center of disc, should always be such that the variations in the velocity of the particles of the disc having contact with the driver will not exceed 4 per cent. A convenient rule which, if followed, will secure this condition, is to make the minimum distance between the driver and the center of the driven disc twelve times the width of the face of the driver. For example, a driver having a $\frac{1}{4}$ inch width of face should be run at a distance of 3 inches or more from the center of the disc. Similarly, drivers having faces $\frac{1}{2}$, 1 or 2 inches in width should be run at a distance from the center of the disc of not less than 6, 12 or 24 inches, respectively. When these conditions are met, all formulæ for calculating the power which may be transmitted, also, the values of Table 10, apply directly to the conditions of face driving.

53 It may not infrequently happen that friction wheels must be run nearer the center of the disc than the distance specified, and there is, of course, no objection to such practice, but it should not be forgotten that as the center of the disc is approached, the coefficient of friction, and consequently, the capacity to transmit power, diminishes.

CONDITIONS TO BE OBSERVED IN THE INSTALLATION OF FRICTION DRIVES

54 Whatever may be the form of the transmission, the fibrous wheel must always be the driver. Neglect of this rule is likely to result in failure which will appear in the unequal wear of the softer wheel, occasioned by slippage.

55 The rolling surfaces of the wheel should be kept clean. Ordinarily, they should not be permitted to collect grease or oil, nor be exposed to excessive moisture. Where this can not be prevented, a factor of safety should be provided by making the wheels larger than normal for the power to be transmitted.

56 Since the power transmitted is directly proportional to the pressure of contact, it is a matter of prime importance that the mechanical means employed in maintaining the contact be as nearly as possible inflexible. For example, arrangements of friction wheels which involve the maintenance of contact through the direct action of a spring have been found unsatisfactory, since any defect in the form of either wheel introduces vibrations which tend to impair the value of the arrangement. It is recommended that springs be avoided and that contact be secured through mechanism which is rigid and which when once adjusted shall be incapable of bringing about any release of the pressure to which it is set.

ACKNOWLEDGMENTS

57 The writer is under obligations to the Rockwood Manufacturing Company of Indianapolis, and especially to Mr. George R. Rockwood of said Company, for supplies of materials and for helpful suggestions, also, to Mr. Paul Diserens, Junior Member of the Society, for assistance rendered in running the tests.

APPENDIX

A SUMMARY OF OBSERVED AND CALCULATED RESULTS

TABLE 1 SUMMARY OF DATA STRAW FIBER

No.	Follower	Revolutions per minute	Slip (per cent)	Contact pressure (pounds per inch)	Coefficient of friction
A	B	C	D	E	F
1	Iron	182	0.56	150	0.153
2	Iron	173	0.58	150	0.179
3	Iron	174	0.61	150	0.213
4	Iron	207	0.78	150	0.271
5	Iron	207	0.99	150	0.313
6	Iron	200	1.10	150	0.359
7	Iron	175	1.40	150	0.386
8	Iron	200	1.22	150	0.381
9	Iron	173	1.94	150	0.411
10	Iron	203	2.25	150	0.458
11	Iron	203	2.79	150	0.473
12	Iron	205	2.33	150	0.463
13	Iron	206	3.15	150	0.465
14	Iron	173	1.04	150	0.368
15	Iron	178	1.75	150	0.405
16	Iron	170	2.00	150	0.432
17	Iron	170	3.90	150	0.446
18	Iron	220	2.02	100	0.430
19	Iron	220	2.00	125	0.431
20	Iron	220	2.10	175	0.432
21	Iron	200	1.80	200	0.436
22	Iron	157	1.62	225	0.440
23	Iron	180	2.20	150	0.420
24	Iron	174	2.10	200	0.427
25	Iron	161	2.25	250	0.422
26	Iron	165	2.02	300	0.405
27	Iron	165	2.02	350	0.401
28	Iron	211	2.12	400	0.410
29	Iron	210	0.65	400	0.129
30	Iron	222	0.87	400	0.217
31	Iron	219	0.88	400	0.228
32	Iron	216	0.90	400	0.234
33	Iron	216	0.93	400	0.275
34	Iron	210	1.16	400	0.318
35	Iron	162	1.80	400	0.400
36	Iron	212	3.00	400	0.435
37	Aluminum	190	0.53	150	0.162
38	Aluminum	195	0.57	150	0.212
39	Aluminum	210	0.60	150	0.215
40	Aluminum	190	0.63	150	0.244
41	Aluminum	195	0.78	150	0.290
42	Aluminum	215	1.26	150	0.372
43	Aluminum	212	1.56	150	0.395
44	Aluminum	200	1.79	150	0.421
45	Aluminum	196	1.90	150	0.446
46	Aluminum	197	3.01	150	0.481
47	Aluminum	193	3.26	150	0.499
48	Aluminum	213	2.12	100	0.464
49	Aluminum	212	1.90	100	0.458
50	Aluminum	213	1.86	125	0.453

TABLE 1 SUMMARY OF DATA STRAW FIBER—Continued

No.	Follower	Revolutions per minute	Slip (per cent)	Contact pressure (pounds per inch)	Coefficient of friction
A	B	C	D	E	F
51	Aluminum	212	2.27	125	0.462
52	Aluminum	212	1.80	175	0.451
53	Aluminum	202	1.86	175	0.471
54	Aluminum	203	2.02	200	0.468
55	Aluminum	214	2.10	200	0.453
56	Aluminum	202	1.80	225	0.445
57	Aluminum	210	2.20	250	0.458
58	Aluminum	210	2.05	300	0.445
59	Aluminum	210	2.15	350	0.437
60	Aluminum	210	1.93	400	0.440
61	Type Metal	214	0.50	150	0.114
62	Type Metal	180	0.58	150	0.164
63	Type Metal	209	0.63	150	0.153
64	Type Metal	223	0.71	150	0.191
65	Type Metal	194	0.73	150	0.199
66	Type Metal	226	0.84	150	0.229
67	Type Metal	187	1.12	150	0.233
68	Type Metal	220	1.18	150	0.244
69	Type Metal	220	1.20	150	0.262
70	Type Metal	188	1.50	150	0.246
71	Type Metal	190	1.54	150	0.252
72	Type Metal	220	1.70	150	0.276
73	Type Metal	187	1.73	150	0.256
74	Type Metal	180	2.01	150	0.290
75	Type Metal	211	2.07	150	0.302
76	Type Metal	180	2.40	150	0.298
77	Type Metal	211	3.48	150	0.317
78	Type Metal	218	3.84	150	0.308
79	Type Metal	209	4.80	150	0.332
80	Type Metal	173	1.70	100	0.327
81	Type Metal	180	1.84	125	0.317
82	Type Metal	208	2.00	150	0.306
83	Type Metal	214	1.90	175	0.295
84	Type Metal	211	2.30	200	0.295
85	Type Metal	209	2.01	225	0.294
86	Type Metal	208	2.10	250	0.288
87	Type Metal	210	2.10	300	0.290

TABLE 2 SUMMARY OF DATA STRAW FIBER BELT DRESSING

No.	Follower	Revolutions per minute	Slip (per cent)	Contact pressure (pounds per inch)	Coefficient of friction
A	B	C	D	E	F
88	Iron	225	0.80	150	0.053
89	Iron	225	0.88	150	0.061
90	Iron	220	1.33	150	0.084
91	Iron	225	1.35	150	0.092
92	Iron	223	1.60	150	0.107
93	Iron	224	2.00	150	0.119
94	Iron	223	2.15	150	0.133
95	Iron	220	2.16	150	0.111
96	Iron	220	3.31	150	0.130
97	Iron	182	2.18	200	0.122
98	Iron	182	2.30	250	0.124
99	Iron	180	2.12	300	0.111
100	Iron	180	2.18	350	0.109
101	Iron	186	2.20	400	0.103
102	Iron	215	2.20	450	0.100
103	Iron	220	2.20	500	0.100

TABLE 3 SUMMARY OF DATA LEATHER FIBER

No.	Follower	Revolutions per minute	Slip (per cent)	Contact pressure (pounds per inch)	Coefficient of friction
A	B	C	D	E	F
104	Iron	179	0.64	150	0.146
105	Iron	175	0.70	150	0.213
106	Iron	167	0.75	150	0.262
107	Iron	178	0.86	150	0.297
108	Iron	180	0.94	150	0.396
109	Iron	170	1.30	150	0.411
110	Iron	210	1.54	150	0.460
111	Iron	208	1.58	150	0.484
112	Iron	208	1.74	150	0.505
113	Iron	208	1.90	150	0.519
114	Iron	190	2.32	150	0.534
115	Iron	168	2.45	150	0.512
116	Iron	168	2.80	150	0.542
117	Iron	191	2.90	150	0.565
118	Iron	206	1.98	200	0.526
119	Iron	200	2.04	250	0.509
120	Iron	200	2.00	300	0.510
121	Iron	200	2.05	350	0.498
122	Iron	220	0.64	300	0.122
123	Iron	200	0.94	300	0.300
124	Iron	198	1.05	300	0.374
125	Iron	190	1.22	300	0.443
126	Iron	211	1.60	300	0.474
127	Iron	190	2.85	300	0.530
128	Aluminum	211	1.92	400	0.481
129	Aluminum	211	2.01	350	0.480
130	Aluminum	211	2.10	300	0.485
131	Aluminum	211	2.15	250	0.502
132	Aluminum	211	2.00	200	0.490
133	Aluminum	211	2.00	150	0.490
134	Type Metal	220	0.75	150	0.163
135	Type Metal	220	0.97	150	0.222
136	Type Metal	220	1.05	150	0.222
137	Type Metal	220	1.30	150	0.254
138	Type Metal	220	1.78	150	0.298
139	Type Metal	220	2.20	150	0.320
140	Type Metal	220	2.75	150	0.336
141	Type Metal	220	3.80	150	0.336
142	Type Metal	216	2.05	200	0.304
143	Type Metal	216	2.08	250	0.311
144	Type Metal	217	2.10	300	0.313
145	Type Metal	207	1.90	350	0.314
146	Type Metal	207	2.00	400	0.310

TABLE 4 SUMMARY OF DATA TARRED FIBER

No.	Follower	Revolutions per minute	Slip (per cent)	Contact pressure (pounds per inch)	Coefficient of friction
A	B	C	D	E	F
147	Iron	220	0.30	150	0.115
148	Iron	220	0.40	150	0.160
149	Iron	220	0.50	150	0.125
150	Iron	220	0.80	150	0.190
151	Iron	220	1.15	150	0.225
152	Iron	219	1.52	150	0.235
153	Iron	218	2.05	150	0.256
154	Iron	220	4.30	150	0.275
155	Iron	220	1.85	200	0.232
156	Iron	220	1.25	250	0.217
157	Iron	220	1.40	300	0.215
158	Iron	220	1.65	350	0.216
159	Iron	220	1.36	400	0.210
160	Iron	220	0.40	400	0.115
161	Iron	220	0.45	400	0.134
162	Iron	216	0.46	400	0.151
163	Iron	219	0.56	400	0.166
164	Iron	220	1.00	400	0.191
165	Iron	220	1.74	400	0.212
166	Iron	222	2.56	400	0.223
167	Aluminum	220	0.30	400	0.062
168	Aluminum	220	0.42	400	0.145
169	Aluminum	221	0.55	400	0.171
170	Aluminum	220	0.55	400	0.212
171	Aluminum	220	0.60	400	0.225
172	Aluminum	216	0.60	400	0.200
173	Aluminum	220	0.72	400	0.235
174	Aluminum	220	0.82	400	0.245
175	Aluminum	220	1.10	400	0.263
176	Aluminum	216	1.20	400	0.270
177	Aluminum	215	1.40	400	0.266
178	Aluminum	216	1.83	400	0.286
179	Aluminum	219	2.50	400	0.300
180	Aluminum	219	3.10	400	0.310
181	Aluminum	220	2.12	150	0.317
182	Aluminum	220	1.70	200	0.300
183	Aluminum	180	2.10	250	0.303
184	Aluminum	180	2.00	300	0.300
185	Aluminum	191	1.90	350	0.295
186	Aluminum	190	2.05	400	0.290
187	Type Metal	230	0.54	400	0.057
188	Type Metal	229	0.63	400	0.083
189	Type Metal	227	0.70	400	0.103
190	Type Metal	227	0.73	400	0.117
191	Type Metal	227	0.80	400	0.140
192	Type Metal	220	1.00	400	0.211
193	Type Metal	220	1.10	400	0.221
194	Type Metal	220	1.26	400	0.220
195	Type Metal	220	1.60	400	0.255
196	Type Metal	220	2.00	400	0.270
197	Type Metal	220	2.75	400	0.285
198	Type Metal	224	2.00	350	0.270
199	Type Metal	225	2.00	300	0.275
200	Type Metal	227	2.00	250	0.270
201	Type Metal	226	2.00	200	0.269
202	Type Metal	227	2.00	150	0.280
267	Iron	210	1.90	200	0.174
268	Iron	211	1.96	300	0.168
269	Iron	210	2.16	400	0.164

TABLE 5 SUMMARY OF DATA LEATHER

No.	Follower	Revolutions per minute	Slip (per cent)	Contact pressure (pounds per inch)	Coefficient of friction
A	B	C	D	E	F
203	Iron	215	0.65	400	0.113
204	Iron	212	0.68	400	0.086
205	Iron	212	0.86	400	0.109
206	Iron	212	0.94	400	0.120
207	Iron	211	0.95	400	0.137
208	Iron	211	1.04	400	0.153
209	Iron	212	1.10	400	0.160
210	Iron	213	1.13	400	0.137
211	Iron	213	1.35	400	0.183
212	Iron	211	1.35	400	0.176
213	Iron	216	1.56	400	0.163
214	Iron	215	1.60	400	0.183
215	Iron	208	2.00	400	0.200
216	Iron	212	2.40	350	0.245
217	Iron	210	2.30	300	0.244
218	Iron	212	2.20	250	0.237
219	Iron	209	1.92	200	0.225
220	Iron	213	2.00	150	0.213
221	Aluminum	211	0.64	300	0.115
222	Aluminum	209	0.80	300	0.160
223	Aluminum	210	1.12	300	0.201
224	Aluminum	213	1.40	300	0.233
225	Aluminum	214	1.70	300	0.260
226	Aluminum	210	1.50	300	0.267
227	Aluminum	210	1.85	300	0.279
228	Aluminum	209	2.45	300	0.310
229	Aluminum	210	3.00	300	0.313
230	Aluminum	211	2.30	350	0.320
231	Aluminum	211	2.00	300	0.305
232	Aluminum	213	1.90	250	0.316
233	Aluminum	214	1.92	200	0.348
234	Aluminum	215	1.92	150	0.380
235	Type Metal	212	1.90	150	0.412
236	Type Metal	213	2.00	200	0.400
237	Type Metal	211	2.10	250	0.389
238	Type Metal	214	2.35	300	0.361
239	Type Metal	214	2.00	350	0.350

TABLE 6 SUMMARY OF DATA SULPHITE FIBER

No.	Follower	Revolutions per minute	Slip (per cent)	Contact pressure (pounds per inch)	Coefficient of friction
A	B	C	D	E	F
240	Iron	211	1.75	150	0.546
241	Iron	211	2.15	200	0.549
242	Iron	210	1.70	250	0.550
243	Iron	211	1.90	300	0.512
244	Iron	210	1.70	350	0.505
245	Aluminum	211	2.00	150	0.535
246	Aluminum	211	2.20	200	0.527
247	Aluminum	211	2.26	250	0.522
248	Aluminum	211	2.10	300	0.520
249	Aluminum	211	2.10	350	0.523
250	Type metal	211	1.80	150	0.505
251	Type metal	211	1.95	200	0.516
252	Type metal	210	1.90	250	0.513
253	Type metal	211	1.75	300	0.490
254	Type metal	212	1.75	350	0.510

TABLE 7 SUMMARY OF DATA STRAW FIBER—IRON

No.	Speed		Slip (per cent)	Contact pressure (pounds per inch)	Coefficient of friction
	Revolutions per minute	Feet per minute			
A	B	C	D	E	F
255	107	450	2.15	200	0.446
256	107	450	2.06	300	0.443
257	107	450	2.02	400	0.412
21	200	836	1.80	200	0.436
26	165	690	2.02	300	0.405
28	211	882	2.12	400	0.410
258	800	3350	2.09	150	0.472
259	800	3350	2.05	200	0.480
260	800	3350	1.91	250	0.440

TABLE 8 SUMMARY OF DATA TARRED FIBER—IRON

No.	Speed		Slip (per cent)	Contact pressure (pounds per inch)	Coefficient of friction
	Revolutions per minute	Feet per minute			
A	B	C	D	E	F
261	107	450	1.88	150	0.290
262	107	450	2.06	250	0.289
263	107	450	1.90	400	0.287
153	218	910	2.05	150	0.256
156	220	920	2.00	250	0.240
166	220	920	2.56	400	0.223
264	800	3350	2.04	150	0.306
265	800	3350	2.10	250	0.287
266	800	3350	1.85	400	0.301

TABLE 9 COEFFICIENT OF FRICTION

	Coefficient of Friction when Contact Pressure is 150 Pounds per Inch		
	Iron	Aluminum	Type Metal
Sulphite Fiber	0.550	0.530	0.515
Leather Fiber	0.515	0.495	0.305
Straw Fiber	0.425	0.455	0.310
Tarred Fiber	0.250	0.305	0.275
Leather	0.225	0.360	0.410
Straw fiber with belt dressing	0.120	—	—

DESIGN OF ENGINES FOR THE USE OF HIGHLY SUPERHEATED STEAM

By MAX E. R. TOLTZ, ST. PAUL, MINN.

Member of the Society

The value of superheated steam and the difficulties encountered in the installation of superheaters in stationary steam plants can be understood more readily by indicating in a brief way the difference between superheated and saturated steam.

2 Saturated steam is steam generated in the steam or water space of the boiler from which in such condition with certain tensions no heat can be abstracted without a percentage of condensation.

3 Superheated steam is a gas which can be expanded to its saturation temperature without being liquefied.

4 Loss of heat in the pipes from the boiler to the steam engine and in the steam engine itself is unavoidable, and therefore a certain part of the saturated steam will condense in those places. This condensation will be in proportion to the moisture contained in the steam. The condensed steam not only does no work, but acts as a hindrance in the steam cylinder. On the other hand if the steam is superheated every particle of water contained in the wet steam will be evaporated.

5 By superheating the steam 200 degrees fahr. above its temperature, its volume increases, owing to pressure, about 25 per cent which augmentation not alone gives more steam, but also reduces the influence of clearance in the cylinder, because superheated steam is more elastic than saturated steam.

To be presented at the New York Meeting (December 1907) of The American Society of Mechanical Engineers, and to form part of Volume 29 of The Transactions.

6 Wilhelm Schmidt, the well known German engineer has found the best way for the production of this highly superheated steam and he was the first to design and build engines adapted for its use. The hope cherished by Schmidt with the introduction of superheated steam was that by means of it the degree of efficiency of the "Carnot" process in the engine could be raised, but in the course of his experiments, it was shown that the practical value of superheated steam rested on the fact only that condensation in the cylinder could be eliminated. It seems that these experiments were not carried on far enough, because according to Garbe (The Locomotives of the Present, 1906, page 223), later tests made by other authorities mentioned elsewhere in this article established quite an economy of heat units with the use of superheated steam, which is expressed in the following diagram:

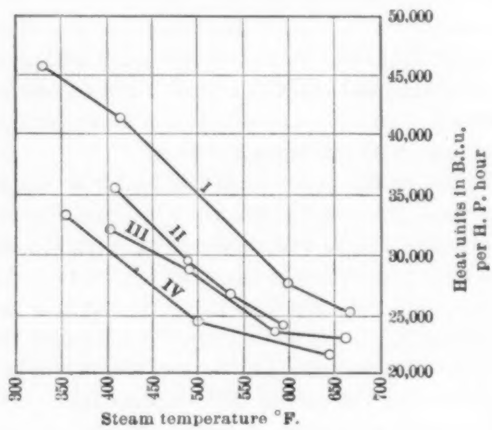


FIG. 1a

Engine type	Cylinder diameter (inches)	Stroke (inches)	R.p.m.	Mean indicated h. p.	Tests made by	Tests carried out with
I	7.1+7.1	11.8	175	16.5	Ripper	Same h. p.
II	12.6	13.8	210	74.4	Doerfel	Same cut-off.
III	9.85	15.7	150	41.25	Seeman	Variable load
IV	9.45	29.5	95	39.4	Gebr. Sulzer	Same i.h.p.

7 At any rate, highly superheated steam having a temperature of from 575 degrees to 625 degrees fahr. should be used to secure the benefit of steam and coal saving, but this can be accomplished only

when the steam engine is designed for the high temperatures of such steam, and it will therefore be necessary to remodel our present engines.

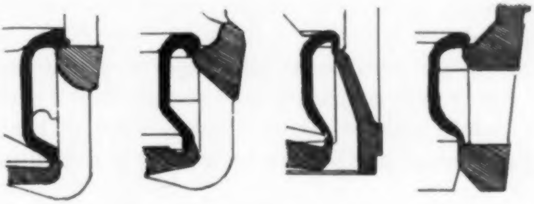


FIG. 1b TYPES OF DOUBLE SEATED POPPET VALVE

8 Before going into the details of such changes, the writer submits three tables showing the steam and coal economy of different types

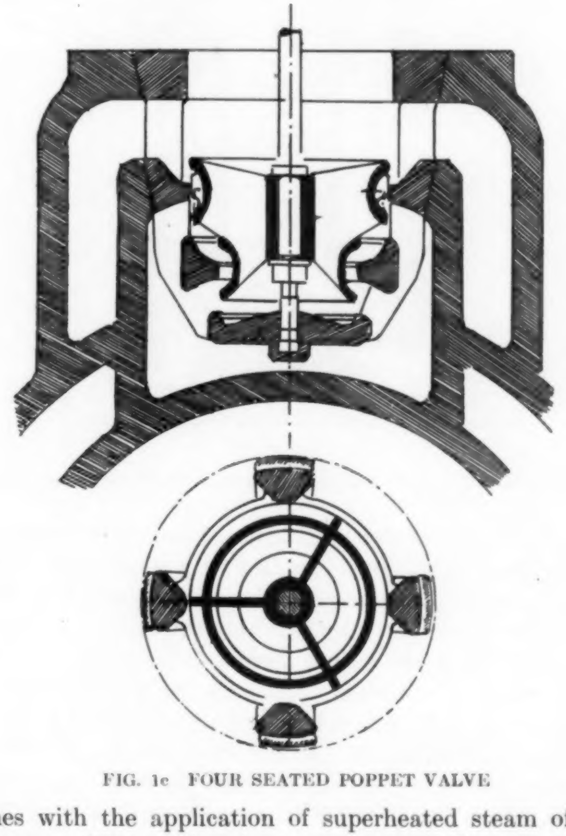


FIG. 1c FOUR SEATED POPPET VALVE

of engines with the application of superheated steam of different temperatures. The results given were compiled by Prof. Hrabak,

Prague, Bohemia, and the writer has enlarged upon them by computing the variable cut-offs to maintain the same power output with the same cylinder dimensions. Attention is called to the low economy of fuel saving where a direct superheat from a separately fired superheater is applied.

9 It is not in the province of this paper to discuss superheaters proper, but their principal feature may be mentioned, which is that a superheater should transmit the highest number of heat units per square foot of heating surface per hour for one degree temperature difference.

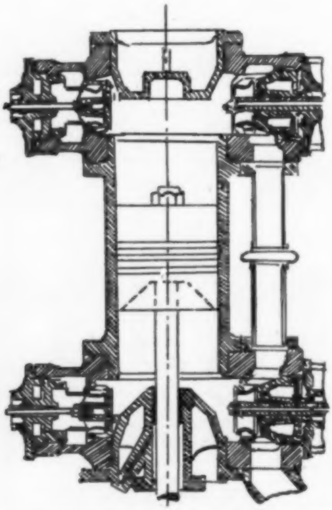


FIG. 1d CYLINDER WITH FOUR VALVES

THE DESIGN OF ENGINES FOR HIGHLY SUPERHEATED STEAM

10 The Corliss valve which has given satisfactory results in saturated steam practice cannot be applied for a steam of very high temperature on account of its large wearing surface, which is difficult to lubricate and which expands by reason of the high heat of the steam so much that it has given serious trouble by sticking.

11 It is generally conceded that a superheat of from 100 degrees to 120 degrees fahr. with a final temperature of the steam of not more than 475 degrees fahr. at the valve is allowable for a Corliss valve. Yet the writer knows of one case in which the final temperature was 497 degrees fahr. This is not high enough, especially in high duty engines, to obtain high economies, therefore, with the use of highly

TABLE 1

Steam and Coal Saving in a Triple Expansion Engine Condensing, of 5000 i.h.p. with Superheated Steam at Different Temperatures

Press. 14 atm.=199 lb.; temp. of sat. steam 381 deg. fahr.; cut-off 4 per cent.; piston speed 16.5 ft. per sec.; automatic cut-of; 4 popped or piston valves per cyl.

Kind of superheat	Degrees of superheat	Temperature of steam	Cut-off constant I.h.p. variable: I.h.p.	Cut-off constant, At engine: Steam consump. per i.h.p. hour lb.	Cut-off constant, At engine, Saving over sat. steam: Steam per cent	Cut-off constant, At engine, Saving over sat. steam: Fuel per cent	Cut-off constant, At boiler: Feed-water per i.h.p. hour in lb.	Cut-off constant, At boiler, Saving over sat. steam: Feed-water per cent	Cut-off constant, At boiler, Saving over sat. steam: Fuel per cent	Cut-off variable. I.h.p constant: I.h.p.	Variation of cut-off per cent	Cut-off variable, At engine: Steam consump. per i.h.p. hour in lb.	Cut-off variable, At engine, Saving over sat. steam: Steam per cent	Cut-off variable, At engine, Saving over sat. steam: Fuel per cent	Cut-off variable, At boiler: Feed-Water per i.h.p. hour in lb.	Cut-off variable, At boiler, Saving over sat. steam: Feed-water per cent	Cut-off variable, At boiler, Saving over sat. steam: Fuel per cent	Remarks
	deg. fahr.	deg. fahr.																
None	0	381	5000	11.82	—	—	12.70	—	—	5000	4.00	11.82	—	—	12.70	—	—	Indirect; superheater in boiler
75 to 150 deg. fahr. Low Indirect	144	525	4350	10.50	11.5	7.5	10.70	16	12	5000	4.85	10.90	7	3.0	11.25	11.5	7.5	Direct superheater separately fired
Direct	144	525	4350	10.50	11.5	−3.0	10.70	16	2	5000	4.85	10.90	7	−8.0	11.25	11.5	−2.5	
150 to 225 deg. fahr. Medium Indirect	216	597	4150	9.81	17.0	10.0	10.03	21	17	5000	5.15	10.32	13	6.0	10.52	17.5	11.0	
Direct	216	597	4150	9.81	17.0	0.0	10.03	21	8	5000	5.15	10.32	13	−4.5	10.52	17.5	1.0	
Double (1) Indirect (2) Direct	216	597	4000	9.15	22.5	12.5	9.35	26	19	5000	5.40	9.60	19	8.5	9.80	23.0	13.5	
(1) Direct (2) Indirect	216	597	4000	9.15	22.5	11.0	9.35	26	17	5000	5.40	9.60	19	6.5	9.80	23.0	12.0	
225 to 290 deg. fahr. High Indirect	288	669	4000	9.15	22.5	13.0	9.35	26	21	5000	5.40	9.60	19	9.0	9.80	23.0	14.0	
Direct	288	669	4000	9.15	22.5	4.0	9.35	26	12	5000	5.40	9.60	19	−1.0	9.80	23.0	5.0	
Double (1) Indirect (2) Direct	288	669	3775	8.48	28.0	16.0	8.70	31	24	5000	5.85	9.20	22	9.0	9.40	26.0	14.5	
(1) Direct (2) Indirect	288	669	3775	8.48	28.0	14.5	8.70	31	22	5000	5.85	9.20	22	7.5	9.40	26.0	13.0	
290 to 360 deg. fahr. Very high Indirect	353	734	3775	8.48	28.0	18.0	8.70	31	25	5000	5.85	9.20	22	11.5	9.40	26.0	16.5	
Direct	353	734	3775	8.48	28.0	8.0	8.70	31	16	5000	5.85	9.20	22	1.5	9.40	26.0	7.0	

TABLE 2

STEAM AND COAL SAVING IN A COMPOUND ENGINE, CONDENSING, OF 250 I.H.P. WITH SUPERHEATED STEAM AT DIFFERENT TEMPERATURES

PRESS. 10 ATM. = 142.23 LB.; TEMP. OF SAT. STEAM 354 DEG. FAHR.; CUT-OFF 6 PER CENT; PISTON SPEED 10 FT. PER SEC.; AUTOMATIC CUT-OFF; 4 POPPED OR PISTON VALVES PER CYL

KIND OF SUPERHEAT	DEGREES OF SUPERHEAT	TEMPERATURE OF STEAM	CUT-OFF CONSTANT. I.H.P. VARIABLE							CUT-OFF VARIABLE. I.H.P. CONSTANT								REMARKS
			I.H.P.	AT ENGINE			AT BOILER			I.H.P.	VARIATION OF CUT-OFF Per cent	AT ENGINE			AT BOILER			
				Steam con-sump. per i.h.p. hour lb.	Saving over sat. steam		Feed-water per i.h.p. hour lb.	Saving over sat. steam				Steam con-sump. per i.h.p. hour lb.	Saving over sat. steam		Feed water per i.h.p. hour lb.	Saving over sat. steam.		
					Steam per cent	Fuel per cent		Feed-water per cent	Fuel per cent				Steam per cent	Fuel per cent		Feed water per cent	Fuel per cent	
	deg. fahr.	deg. fahr.																
NONE	0	354	250	14.72	—	—	15.73	—	—	250	6.00	14.72	—	—	15.73	—	—	Indirect; super-heater in boiler
75 to 150 deg. fahr.																		
LOW Indirect	130	484	225	12.25	15.0	11.0	12.50	21	17	250	6.95	12.50	15.0	11.5	12.70	20.0	16.0	Direct super-heater separate-ly fired
Direct	130	484	225	12.25	15.0	1.5	12.50	21	8	250	6.95	12.50	15.0	1.5	12.70	20.0	7.0	
150 to 225 deg. fahr.																		
MEDIUM Indirect	202	556	215	11.60	21.0	15.0	11.81	25	21	250	7.50	11.75	20.0	14.0	11.98	24.5	18.5	
Direct	202	556	215	11.60	21.0	5.5	11.81	25	12	250	7.50	11.75	20.0	4.5	11.98	24.5	9.5	
DOUBLE (1) Indirect (2) Direct	202	556	205	10.70	27.5	18.0	10.93	31	24	250	8.00	10.85	26.0	17.0	11.09	30.0	21.0	
(1) Direct (2) Indirect	202	556	205	10.70	27.5	16.5	10.93	31	23	250	8.00	10.85	26.0	15.0	11.09	30.0	19.5	
225 to 290 deg. fahr.																		
HIGH Indirect	274	628	205	10.70	27.5	19.0	10.93	31	27	250	8.00	10.85	26.0	17.5	11.09	30.0	21.5	
Direct	274	628	205	10.70	27.5	10.0	10.93	31	17	250	8.00	10.85	25.0	8.5	11.09	30.0	13.0	
DOUBLE (1) Indirect (2) Direct	274	628	198	10.27	30.0	18.5	10.50	34	26	250	8.50	10.51	28.5	16.0	10.75	32.0	20.5	
(1) Direct (2) Indirect	274	628	198	10.27	30.0	17.0	10.50	34	25	250	8.50	10.51	28.5	15.0	10.75	32.0	19.0	
290 to 360 deg. fahr.																		
VERY HIGH Indirect	338	692	198	10.27	30.0	20.5	10.50	34	28	250	8.50	10.51	28.5	18.5	10.75	32.0	22.5	
Direct	338	692	198	10.27	30.0	11.5	10.50	34	20	250	8.50	10.51	28.5	9.0	10.75	32.0	13.5	

TABLE 3

STEAM AND COAL SAVING IN A SIMPLE-NONCONDENSING ENGINE OF 250 I.H.P. WITH SUPERHEATED STEAM AT DIFFERENT TEMPERATURES

PRESS. 12 ATM = 177 LB.; TEMP. of SAT. STEAM 369 DEG. FAHR.; CUT-OFF 20 PER CENT; PISTON-SPEED 10 FT. PER SEC.; SLIDE OR PISTON VALVE; CHANGE OF CUT-OFF EFFECTED BY VALVE GEAR

KIND OF SUPERHEAT	DEGREES OF SUPERHEAT	TEMPERATURE OF STEAM	CUT-OFF CONSTANT. I. H. P. VARIABLE							CUT-OFF VARIABLE. I.H.P. CONSTANT								REMARKS
			I.H.P.	AT ENGINE			AT BOILER			I.H.P.	AT ENGINE			AT BOILER				
				Steam con-sump. per i.h.p. hour lb.	Saving over sat. steam		Steam con-sump. per i.h.p. hour lb.	Saving over sat. steam			Steam con-sump. per i.h.p. hour lb.	Saving over sat. steam		Steam con-sump. per i. h. p. hour lb.	Saving over sat. steam			
					Steam per cent	Fuel per cent		Feed-water per cent	Fuel per cent			Steam per cent	Fuel per cent		Feed-water per cent	Fuel cent per		
	deg. fahr.	deg. fahr.																
NONE	0	369	250	27.00	—	—	29.00	—	—	250	27.00	—	—	29.00	—	—	20.00	Indirect; super-heater in boiler
75 to 150 deg. fahr.																		
LOW Indirect	103	472	235	21.00	22.0	18.5	21.40	27	23	250	21.05	22.0	18.5	21.47	26.0	22.5	20.88	Direct; super-heater separate-ly fired
Direct	103	472	235	21.00	22.0	10.0	21.40	27	14	250	21.05	22.0	9.5	21.47	26.0	14.0	20.85	
150 to 225 deg. fahr.																		
MEDIUM Indirect	162	531	230	19.85	26.5	20.5	20.10	30	27	250	20.00	25.5	20.0	20.40	29.5	24.0	21.35	
Direct	162	531	230	19.85	26.5	21.5	20.10	30	19	250	20.00	25.5	11.0	20.40	29.5	15.5	21.35	
225 to 290 deg. fahr.																		
HIGH Indirect	234	603	222	18.50	31.0	23.0	18.85	35	31	250	18.75	30.5	22.0	19.13	34.0	26.0	21.75	
Direct	234	603	222	18.50	31.0	15.0	18.85	35	22	250	18.75	30.5	13.5	19.13	34.0	18.0	21.75	

superheated steam as referred to above, it is necessary to replace the Corliss valve by double seated poppet valves for engines of moderate size and slow piston speed and, for large engines of high piston speeds, by four seated poppet valves. It is also advisable to apply piston valves. The illustration Fig. 2a, shows the "Schmidt" solid piston valve which has the interesting feature of being jacketed by superheated steam. The other valve, Fig. 2b used in Belgium mostly, has one solid ring with several grooves and small holes for the purpose of leading any steam that may leak through from the admission side to the back of the ring, so enabling it to act as a spring thus giving it closer contact. One or four of either type of valve for one cylinder can attend to the distribution of steam.

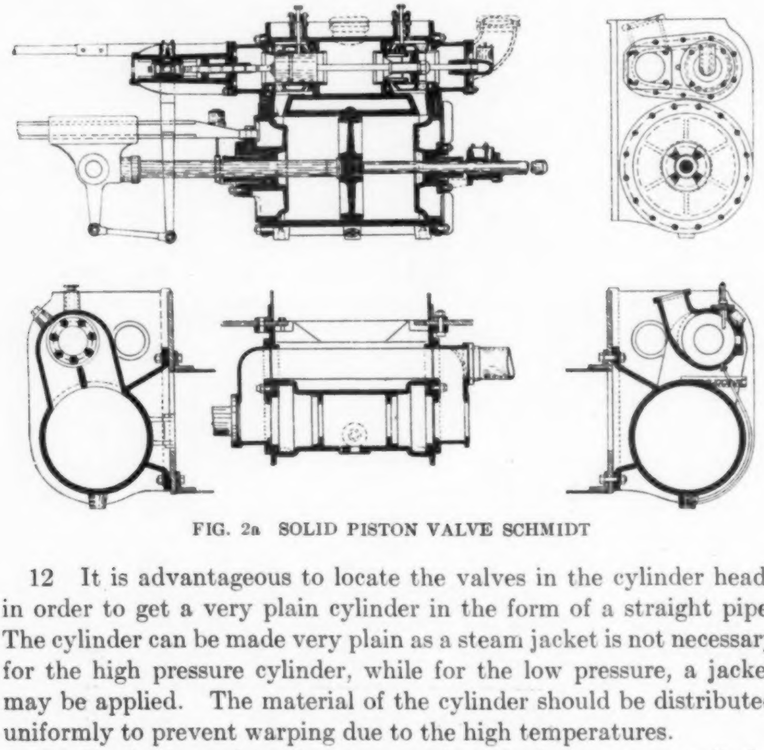


FIG. 2a SOLID PISTON VALVE SCHMIDT

12 It is advantageous to locate the valves in the cylinder heads in order to get a very plain cylinder in the form of a straight pipe. The cylinder can be made very plain as a steam jacket is not necessary for the high pressure cylinder, while for the low pressure, a jacket may be applied. The material of the cylinder should be distributed uniformly to prevent warping due to the high temperatures.

13 For horizontal tandem type engines the low pressure cylinder should, whenever possible, be located on the frame and the high pressure cylinder in the rear, which arrangement will at the same time reduce any heating in the cross head guides.

14 The tandem type is recommended on account of being able

to work the engine with high piston speed which means low first cost of the engine.

15 Although it is generally understood that poppet valve engines can run only at about 120 to 150 r.p.m., the latest types in Europe are designed for 230 to 240 r.p.m., while in this country they are now being built for any speed up to 300 r.p.m. The writer has so far not been able to corroborate the latter statement, which was made during the last Indianapolis Meeting.

16 If valve casings are cast on the cylinder, it should be done in a very plain manner, but no steam channels should be cast on in con-

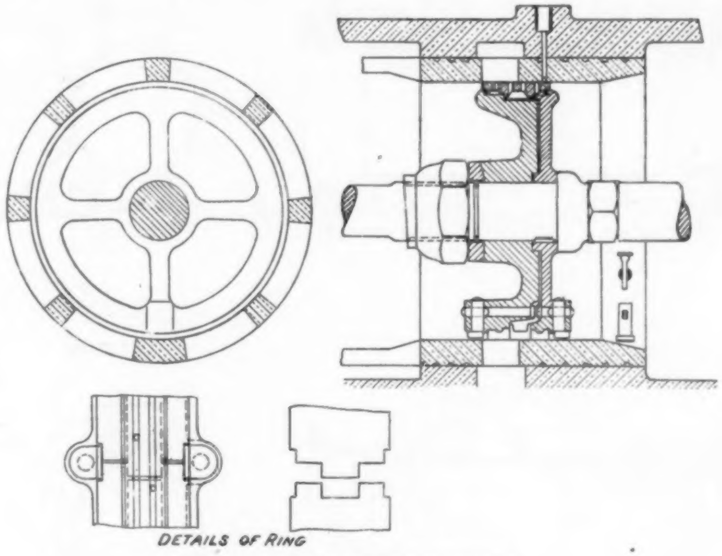


FIG. 2b BELGIAN PISTON VALVE

nection therewith. Each valve casing should be provided with a flange to make pipe connection for admission as well as exhaust steam.

17 The piston should have at least three rings of good width. For horizontal engines it should be guided outside of the cylinder by the cross head and an extra liberal bearing for the extended piston rod so that the piston body will not ride on the cylinder wall.

18 The piston should be lubricated directly and not by mixing the oil with the admission steam.

19 The packing of the piston rod should consist of metallic rings of a composition adapted to stand the high temperature. A composition of 80 per cent antimony and 20 per cent lead has given good results. At the same time the stuffing boxes should be arranged so

as to offer plenty of cooling surface to the outside air in order to reduce the temperature.

20 The cylinder dimensions of the saturated steam engine are based upon an economical cut-off, and the reduction of this cut-off is limited by the increasing condensation which takes place when the cut-off is decreased beyond a certain minimum. To improve this feature, the compound, triple and quadruple expansion engines have been introduced; in which, on account of the smaller temperature

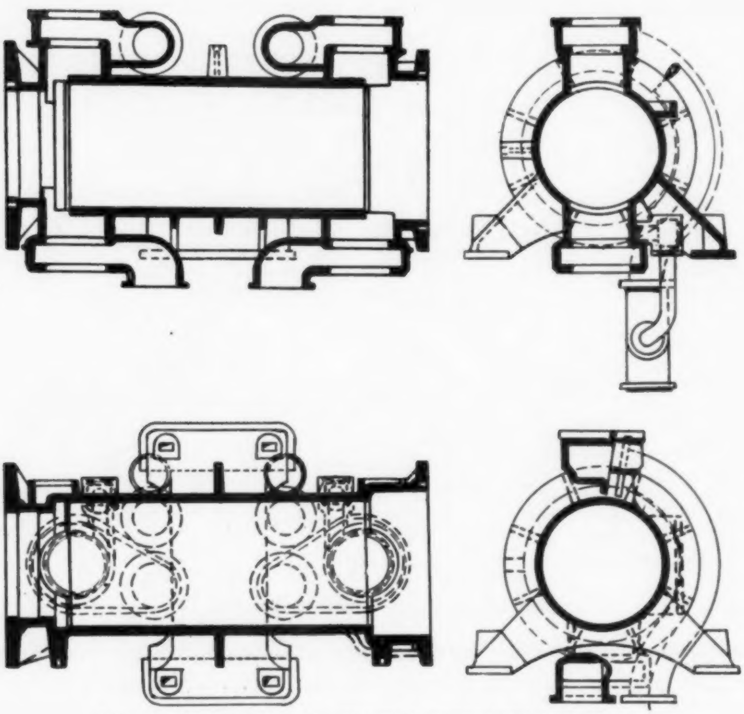


FIG. 4 CYLINDER FOR HIGHLY SUPERHEATED STEAM

differences between the admission and the exhaust steam in the different cylinders, condensation has been decreased materially.

21 In an engine for superheated steam, the degree of expansion can be brought to a higher state of perfection, because it is only a question of superheating the admission steam high enough to eliminate condensation entirely. Therefore, the cut-off should be reduced, but the cylinder dimensions should be enlarged in proportion so as to be equivalent to the saturated steam engine.

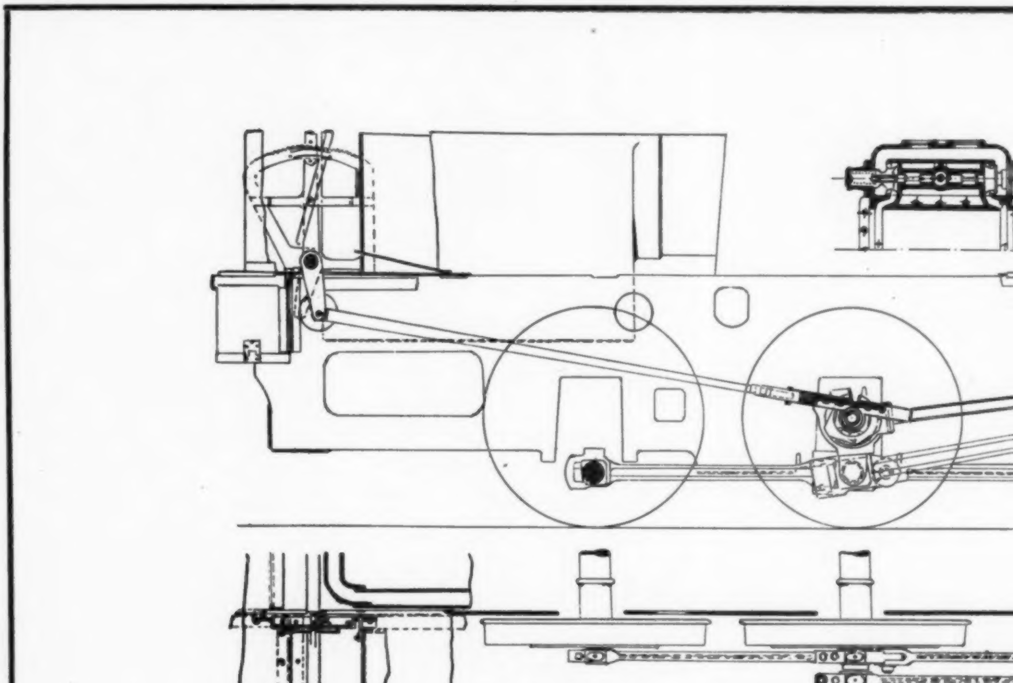
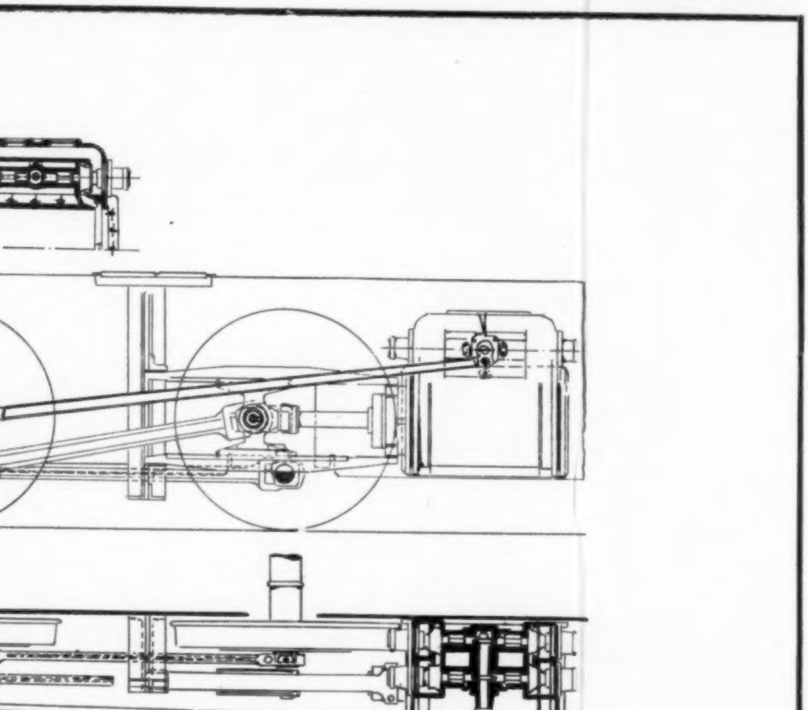


FIG. 3 LENTZ VALVES AND GEAR FOR LO



AR FOR LOCOMOTIVES

22 On existing engines the speed should be increased if it is mechanically possible. Although this change calls for higher steam velocities in the steam channels and valves it must be borne in mind

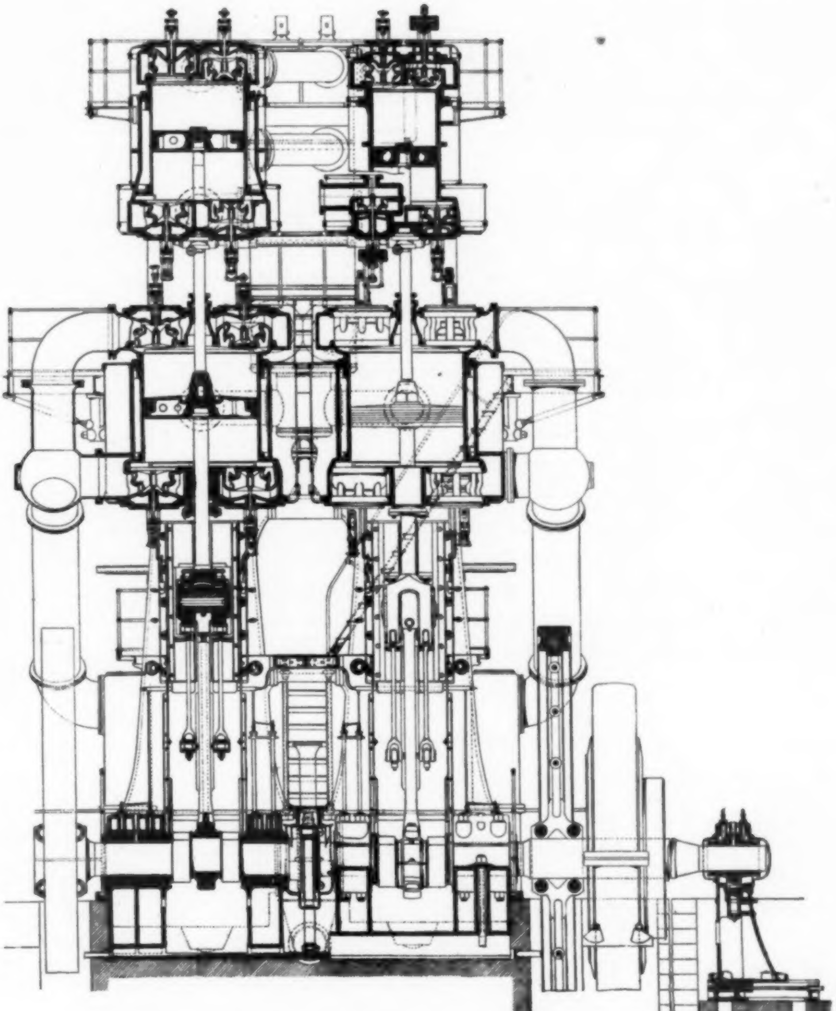


FIG. 5 3000 H. P. INSTALLED AT ELECTRICAL WORKS, BERLIN. BUILT BY SULZER BROS.

that superheated steam can attain velocities from 40 per cent to 60 per cent greater than that of saturated steam without showing a throttling line of expansion on an indicated diagram.

STYLE SHEET

A Guide for Authors, Editors, Compositors, Proof-readers, in the Make-up, etc., of Printed Matter

This Style Sheet is adopted for guidance in editorial writing, composition, proof-reading and make-up of the publications of The American Society of Mechanical Engineers. It means that copy is to be edited to conform to these rules before going to the printer and that proof is to be corrected in accordance with them. No deviations are to be made from these rules for use on any paper, or for any author, without the concurrence of the Publication Committee or the Secretary, or both, as elsewhere provided.

2 All printers, bookbinders and others who work for the Society, and all members of the office staff who produce, edit or proof-read copy are expected to familiarize themselves with these simple rules and learn to conform to them, so that our work may be done with accuracy, economy, despatch and a uniform style.

3 Questions arising and not fully answered by these instructions should be reported to the editor, also wherever the wisdom of instructions herein contained is seriously questioned the matter should be taken up with the editor.

AUTHORITIES

4 The Century Dictionary (for spelling and use of words), Dewey's Library Editing and Printing (editorial practice), DeVinne's Correct Composition and Plain Printing Types (typography), and the Government Printing Office Manual of Style (spelling proper names especially) are to be followed in matters not herein specifically mentioned.

TYPE FACES

5 All printed matter will be set in one of three faces of type;

a Caslon Old Style for all circulars, and advertising matter.

This article is offered only as the basis of a Style Sheet for the Society's publications, and is subject to changes and alterations. It is hoped the members will submit suggestions, all of which will be referred to the Standardization Committee for consideration.

b Gothic for business forms, books of account, and printed matter used entirely within the office; also for all forms used in the accounting department such as vouchers, checks, etc., whether used entirely within the office or not.

c Modern for all publications.

6 Stationery will be lithographed from a script letter except that for members use which will be embossed with a die cut in gothic letters.

ABBREVIATIONS

7 Follow the author as largely as possible with respect to abbreviation or non-abbreviation. When abbreviations are used they must conform to the following specifications.

8 The general policy will be to abbreviate too little rather than too much. However where a word is used which has a recognized abbreviation, and especially those which are listed below, the abbreviation should be used unless there is a good reason for not doing so.

9 This practice is formulated for the use of abbreviations in the text. It occasionally happens in tabular work, and especially in headings, that it is not possible to follow the text style. No change however from this style should be made which will render the matter difficult to read. There should be a very good reason for every departure from the forms given here even in tabular work.

10 In abbreviating avoid symbols wherever possible. Never use the characters (′) or (″) to indicate feet and inches, or minutes and seconds as periods of time.

11 Use abbreviations only after nouns denoting a definite quantity. Example: The power plant has a capacity of ten h.p., not 10 horse power: but, The capacity of the plant, in horse power, is ten.

12 Do not abbreviate abstract or descriptive words. Example: horizontal return tubular boilers, not h.r.t. boilers.

13 Use lower case characters for abbreviations. An exception to this rule may be made in the case of words spelled normally with a capital. Example: B.t.u. and not b.t.u or B.T.U. (British thermal unit): U. S. gal. (United States gallon), B & S gage (Brown and Sharpe gage).

14 Use a period after each abbreviation. In a compound abbreviation, do not use a space after the period. Example: i.h.p. and not i. h. p. (indicated horse power).

15 Use a hyphen to connect abbreviations in cases where the words would take a hyphen if written out in full. When a hyphen

is used, omit the period immediately preceding the hyphen. Example: 3 kw-hr. and not three kw.-hr. (3 kilowatt-hours).

16 Use all abbreviations in the singular. Example: 17 lb. and not 17 lbs. (17 pounds): 14 in., not 14 ins. (14 inches).

17 Spell out the names of the months as January 25. Do not use st, d, or th with the numerals.

18 In general, spell out an adjective qualifying the name of a unit. Example: boiler h.p. (boiler horse power). The exceptions to this rule are: i.h.p. (indicated horse power), e.h.p. (electric horse power), b.h.p. (brake horse power), e.m.f. (electromotive force), m.m.f. (magnetomotive force).

19 Use Fig., not figure. Example: Fig. 3, and not Figure 3.

20 Spell out names of companies, railroads, etc., using the ampersand (&) only between proper names. Examples: Brown & Sharpe Manufacturing Company, Norfolk & Western Railroad, but American Smelting and Refining Company.

21 Abbreviate Company (Co.) in firm names: John Brown & Co. In giving a title, use Dr., Prof., Gen. etc., where initials or full name is given: spell out where surname only is given.

22 The following abbreviations will be used:

Afternoon	p.m.
American Society of Mechanical Engineers	spell out except after the name of a member.
Amperes	spell out
Associate	Assoc. Am. Soc. M. E.
Barrels	bbl.
Birmingham wire gage	B.w.g.
Brake horse power	b.h.p.
British thermal units	B.t.u.
Brown & Sharpe (gage)	B. & S.
Bushels	bu.
Calories	cal.
Candle power	c.p.
Centiliter	cl.
Centigrade	cent.
Centigram	cg.
Centimeter	cm.
Chemically pure	c.p.
Circular mils	cir.mils
Cosine	cos.
Cotangent	cot.
Cubic	cu.
Decaliter	dal.
Decigram	dg.
Deciliter	dl.

Decimeter	dm.
Degrees	deg.
Diameter	spell out
Electric horse power	e.h.p.
Electromotive force	e.m.f.
Fahrenheit	fahr.
Feet	ft.
Forenoon	a.m.
Gallons	gal.
Grains	gr.
Gram	g.
Gram-calories	g-cal.
Hectare	ha.
Hectoliter	hl.
High-pressure cylinder	spell out
His Majesty's Ship	H.M.S.
Honorary Members	Hon.Mem.Am.Soc.M.E.
Horse power	h.p.
Hours	hr.
Inches	in.
Indicated horse power	i.h.p.
Juniors	Jun.Am.Soc.M.E.
Kilogram	kg.
Kilogram-calories	kg-cal.
Kilogram-meters	kg-m.
Kilometer	km.
Kilowatt-hours	kw-hr.
Kilowatts	kw.
Linear	lin.
Liter	l.
Magnetomotive force	m.m.f.
Mean effective pressure	spell out
Members	Mem.Am.Soc.M.E.
Meter	m.
Meter-kilograms	m-kg.
Miles	spell out
Miles per hour per second	miles per hr. per sec.
Milligram	mg.
Milliliter	ml.
Millimeter	mm.
Minutes	min.
Months	spell out
Number	no.
Ohms	spell out
Ounces	oz.
Per	spell out
Percentage	per cent
Pounds	lb.
Proceedings	Proc.
Revolutions per minute	r.p.m.

Seconds	**sec.**
Sine	**sin.**
Specific gravity	**sp.gr.**
Square	**sq.**
Stere	**s.**
Tangent	**tan.**
Tons	**spell out**
Transactions	**Trans.**
United States (gage)	**U.S.**
United States Ship	**U.S.S.**
Volts	**spell out**
Volume	**vol.**
Watt-hours	**watt-hr.**
Watts	**spell out**
Watts per candle-power	**watts per c-p.**
Yards	**yd.**
Years	**spell out**

23 The following abbreviations will be used in the Pocket List of members and in the Year Book. Ordinarily the name of the member will be spelled out exactly as the member writes it. The abbreviations of given names will be used only in first names and occasionally in the Pocket List where it is absolutely necessary to gain space. Where no abbreviation is furnished the word will be spelled out.

Agent	**Agt.**
American	**Am.**
Architect	**Arch.**
Assistant	**Asst.**
Associate	**Assoc.**
Attorney	**Atty.**
Auditor	**Audr.**
Avenue	**Ave.**
Board	**Bd.**
Brothers	**Bros.**
Building	**Bldg.**
Borough	**Boro.**
Captain	**Capt.**
Chemist	**Chem.**
Chief	**Ch.**
College	**Coll.**
Committee	**Com.**
Commissioner	**Comr.**
Company	**Co.**
Consolidated	**Consol.**
Construction	**Constr.**
County	**Co.**
Department	**Dept.**
Director	**Dir.**
Draftsman	**Spell out**
East	**E.**
Electric	**Elec.**
Engine	**Eng.**
Engineering	**Engrg.**
Engineer	**Engr.**
Executive	**Exec.**
Civil Engineer	**Civ. Engr.**
Constructing Engineer	**Constr. Engr.**
Consulting Engineer	**Cons. Engr.**
Contracting Engineer	**Contr. Engr.**
Electrical Engineer	**Elec. Engr.**
Heating Engineer	**Heat. Engr.**
Hydraulic Engineer	**Hyd. Engr.**
Marine Engineer	**Mar. Engr.**
Mechanical Engineer	**Mech. Engr.**
Mining Engineer	**Min. Engr.**
Refrigerating Engineer	**Refrig. Engr.**
Ventilating Engineer	**Vent. Engr.**
Equipment	**Equip.**
Foundry	**Fdy.**
General	**Genl.**
Honorable	**Hon.**
Incorporated	**Inc.**

Inspection	Inspc.	Post Office	P. O.
Inspector	Inspr.	President	Pres.
Institute	Inst.	Professor	Prof.
Instructor	Instr.	Proprietor	Prop.
Insurance	Ins.	Railroad	R.R.
International	Internatl.	Railway	Ry.
Lieutenant	Lieut.	Representative	Rep.
Limited	Ltd.	Resident	Res.
Locomotive	Loco.	Secretary	Secy.
Machine	Mch.	South	S.
Machinery	Mchy.	Street	St.
Manager	Mgr.	Superintendent	Supt.
Manufacturer	Mfr.	Superintending	Suptg.
Manufacturing	Mfg.	Technical	Tech.
Master Car Builder	M.C.B.	Treasurer	Treas.
Master Mechanic	M.M.	United States	U. S.
Mechanical	Mech.	United States Army	U.S.A.
Mining	Min.	United States Navy	U.S.N.
Motive Power	M.P.	University	Univ.
National	Natl.	Vice President	V. P.
North	N.	West	W.
Place	Pl.	Works	Wks.
Pneumatic	Penu.		

24 Abbreviations of States to be used in Year Book, Pocket List and all publications.

Ala.	Ky.	N. Y.
Alaska	La.	O.
Ariz.	Mass.	Okla.
Ark.	Md.	Oreg.
Cal.	Me.	Pa.
Colo.	Mich.	R. I.
Conn.	Minn.	S. C.
Del.	Miss.	S. D.
D. C.	Mo.	Tenn.
Fla.	Mont.	Tex.
Ga.	N. C.	Utah
Ia.	N. Dak.	Va.
Idaho	Neb.	Vt.
Ill.	Nev.	Wash.
Ind.	N. H.	W. Va.
Ind. Ter.	N. J.	Wis.
Kan.	N. Mex.	Wyo.

USE OF NUMERALS

25 Roman numerals will not be used. When an author uses this system for enumeration another shall be substituted. If the copy lists a series of statements as 1, 2, 3, etc., change to A, B, C, or a, b, c.

If under either of these enumerations a further subdivision is called for use 1,2,3. This will prevent the series of numbers indicating the paragraphs from clashing with the series enumerating the statements. Do not allow two series of numbers to be used together unless they have letters between them. Do not begin a sentence with figures.

26 SPELL OUT ALL NUMBERS FROM ONE TO TWELVE excepting in the following cases where numerals will be used.

27 When the number is followed by a decimal or common fraction; never spell out $1\frac{1}{3}$, $2\frac{3}{4}$, etc. Common fractions for which there are no màtrices should be expressed thus: 4/18.

28 When the number is followed by a word having an authorized abbreviation, as 2 ft., 6 oz., 1 in. *EXCEPTING* when the statement is vague in its nature, as when the word "about" is used or implied, as in "some six feet beyond," when spell out.

29 In a series of two or more connected or contrasted numerical statements, if some of the numbers must be numerals, use numerals for all as "2 men were killed and 16 or 18 injured."

30 In a series of connected numerical statements where precision is implied, use numerals only: as "2 foremen, 7 masons, 8 laborers."

31 Use numerals in such expressions as 7-story building, and 3-mile railway. And when one number immediately follows another spell out one, preferably the smaller one; as six 4-inch bolts.

32 Use numerals following such abbreviations as vol., fig., no., etc., where the numbers are used in an enumeration.

33 USE NUMERALS FOR ALL NUMBERS EXCEEDING TWELVE except where round numbers are used in a vague sense, as in "A thousand men taken at random," or "Five hundred different reasons may be given," where they should be spelled out; or where a sentence begins with a number.

34 In all decimal numbers having no units a cipher should be placed before the decimal point. Example: 0.32 lb., not .32 lb.

35 Omit unnecessary ciphers in sums of money. Example: $3 not $3.00.

36 Use decimals, as far as possible, in place of common fractions. Example: 1.25 ft., not $1\frac{1}{4}$ ft.

37 In numbers larger than four figures use en spaces instead of commas. Example: 1 520 125, not, 1,520,125. Do not point off numbers of four figures or less.

38 In tabular work, however, when a table contains any number of more than four figures, the numbers of four figures must also be pointed off.

39 Use the word by instead of letter x in giving dimensions. Example: 8 by 12 in., not 8 x 12 in.

40 Always use figures for the day of the month when the month is given (January 25), before per cent (6 per cent), for the time of day (2.30 o'clock), and for ages of persons.

41 Use the English system for dimensions, etc.; bracket the metric equivalents if necessary.

CAPITALS

Use capitals sparingly.

42 North, South, East, West, etc., should be capitalized when they refer to a portion of the country, but not otherwise. Examples: Conditions in the South, a Western miner, but in western New York, southern Illinois.

43 Capitalize State when it refers to a State of the Union, not otherwise. Capitalize Federal, Government, Constitution, Cabinet Administration, when they refer to U. S. Government, and President when referring to the President of the United States.

44 Capitalize titles of offices when used before personal names and immediately after where the name of the firm is given, as in the Year Book and Pocket List. Do not capitalize titles of offices when used in any other form.

45 Use lower case in the following: bessemer steel, plaster of paris, german silver, portland cement, india rubber, babbitt metal, roman face, etc.

46 County, river, creek, mine, district, street, etc., should be set in lower case.

47 Capitalize the principal words in headings, titles of books, papers, etc. (nouns, verbs, adjectives and adverbs).

48 In references do not capitalize volume, figure, plate, paper, etc.

QUOTATION MARKS

Use quotation marks as little as possible.

49 When a word, phrase or sentence is reproduced from another place it will be included within quotation marks when it is preceded and followed by original matter. A quoted article following an introduction paragraph needs no quotation marks except when it is followed by original matter. Longer quotations will be distinguished by change of type. Occurring in 10 point, quotations will be set in 8 point; occurring in 8 point, in 6 point. Occurring in 6 point,

quotes at the beginning and end of the quotation will invariably be used.

50 In these, and all other cases of change of type, the two kinds of matter will be separated by a 10 point lead both above and below.

51 The names of ships, railway cars, engines and the like, and periodicals will be set in roman, capitalized when it is proper to do so under our rules but not quoted. The words Transactions and Proceedings standing alone will represent our publications. When referring to other transactions or proceedings use the name of the organization thus: Proceedings of the American Institute of Electrical Engineers.

FOOTNOTES

Avoid footnotes. Try to arrange the matter so that it can be set in the text.

52 Footnotes will be set in 8 point with 2 point lead. Where the the footnote occurs on a page of 8 point, it will be set in 8 point solid. They are to be set off from the page by a 10 point space without rule. Where the line is less than the full page measure in length center it. otherwise indent one em space.

53 Use superior figures instead of asterisks, etc., except in mathematical work where confusion might arise when letters are used.

54 The routine note at the bottom of the page beginning a paper, giving the place and time at which the paper was or is to be presented need not be referred to by a number.

ITALICS AND SMALL CAPS

55 Set foreign words, phrases, etc., in italic. Set algebraic quantities and formulae in italic; chemical symbols in roman. Use italics and small caps sparingly.

HYPHEN

56 Compound adjectives should be hyphenated. Examples: high-grade ore, 24-inch lathe, pig-iron market.

57 Do not hyphenate words which stand in regular syntactical relation as adverb and adjective. Example: newly painted house, not newly-painted house.

Hyphenate the following:

cut-off	**eye-bar**
drop-press	**hammer-head**

high-duty
high-pressure
high-priced
high-speed
horse-power
hot-well
low-duty
low-pressure
low-priced
low-speed
make-ready
make-up
multiple-cylinder
open-hearth
single-cylinder
triple-expansion

58 Use the hyphen in such combinations as the following but not when they stand alone; in other words the hyphen is used only to avoid an obscure meaning:

belt-testing machine
built-up work
cost-keeping system
direct-acting mechanism
direct-connected engine
double-screw ferryboat
gear-cutting machine
hot-air engine
ingot-heating furnace
internal-combustion engine
lathe-tool dynamometer
oil-testing machine

59 With the following do not use a hyphen:

air compressor
bevel gear
blue print
boiler room
candle power
cast iron
cast steel
connecting rod
crank pin
crank shaft
drafting room
engine room
fire tube
gas engine
gas producer
gas regulator
gas turbine
hot water heating system
latent heat
machine shop
machine tool
passenger car
piston rod
power plant
printing press
railroad car
rod mill
rolling mill
shop order
specific heat
sper gear
stan bolt
steam jacket
steam turbine
steam boiler
steam heating or heat
steam piping or pipe
steam power plant
step bearing
street car
street railway
valve gear
water meter
water power
water tube
water works
worm gear
wrought iron
yield point

PARAGRAPHING

60 Paragraphs shall begin with a one em indention and shall be numbered consecutively for each paper. Do not use a period after the paragraph number. Number every paragraph where it exceeds a line in length. The numbering of the paragraphs of the discussion shall be continuous with the remainder of the paper. The paragraph number of the first paragraph of every piece of discussion shall be dropped as it conflicts with the name.

MISCELLANEOUS

61 In the absence of any other title use the title Mr. both when initials are given and when they are not given. Give name in full when at all appropriate to do so. Avoid the use of foreign equivalents of Mr. except in quoting translated matter.

62 Degrees, honorary or otherwise, will not be used in connection with names in the publications of the Society.

63 In giving references to our own or other publications, give the name of the publication first, then the volume, and then the various subdivisions in order of their relative importance. Thus Transactions, vol. 26, no. 1206, par. 727; or Proceedings, vol. 28, Art of Cutting Metals, plate 27, fig. 14.

64 No printer's mark or the name of any individual or concern connected with the manufacturing of any part of the work will be used.

65 A uniform size of paper (8½ by 11) for copy will be adopted. Allowing margins of 1½ inches at the left hand side and one inch at the top.

TYPOGRAPHY OF PROCEEDINGS

SIZE OF TYPE AND TYPE PAGE

66 All reading matter is to be set in 10 point on a 12 point body, 8 point on 10 point body, or in 6 point on 8 point body, or solid. Examples:

The opening exercise of the Dedication of the Engineering Societies Building was held in the Auditorium on Tuesday afternoon, April 16, with Mr. Charles Wallace Hunt as Presiding Officer. The distinguished guests who addressed the audience were Rev. Edward Everett Hale, Andrew Carnegie, and Arthur Twining Hadley. Richard Arnold's Double Sextette rendered Handel's "Largo," after which the Presiding Officer opened the meeting.

Columbia University tenders warmest congratulations to the Engineers of America upon the occasion of the dedication of their new home and pledges her coöperation in the great work of maintaining and increasing the dignity and usefulness of that profession in which the genius of the American people is perhaps most typically exemplified.

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67 Original matter is to be set in 10 point, unless otherwise provided.

68 Tabular matter without rules in 8 point, and tabular matter with rules in 6 point.

69 Reports of standing committees, reports of special committees, where not made the subject matter of separate papers, resolutions, lists of names, appendices, matter introduced by the word "Note," are to be set in 8 point when occurring in 10 point matter, and in 6 point when occurring in 8 point matter.

70 Size of page shall be 25 pica ems wide and 44 pica ems deep, approximately $4\frac{1}{8}$ by $7\frac{5}{16}$ in. There shall be no deviation from this measure except as may be specially provided. For giving special prominence to matter, change in size of type or spacing shall be used, rather than change of measure.

HEADLINES

71 Headlines are to be set in 10 point small caps without punctuation. The page numerals will be set as a part of the page headings. Example:

SUPERHEATED STEAM ON LOCOMOTIVES 1623

Either the title of the paper or some abbreviation of it, which will go in the line, shall be repeated as the page headings. The same head will be used throughout the paper. Unless absolutely necessary, this title should not be more than three inches in length. The heading will be separated from the page by a one em space. Where subheads are used page headings will be omitted.

HEADS

Heads to be used for paper and sections will be distinguished as No. 1, No. 2, etc.

72 When used in Transactions every paper head will have above it and separated by a 14 point space from the title line a serial paper number set in 8 point Engravers Roman:

(Sink 1 in. from point of headline)

No. 1096

(14 pt. space)

ANALYSIS OF LOCOMOTIVE TESTS

(28 pt. space)

73 Heads will be sunk one inch from the top of the paper and will be separated from the text by a 28 point space.

74 Head No. 1 consists of a single line title set in 10 point No. 524 Lining Title all caps. When the title cannot be expressed in a single line, center the second line. Example:

(Sink 1 in. from point of headline)

THE ORDNANCE DEPARTMENT AS AN
ENGINEERING ORGANIZATION

(28 pt. space)

75 Head No. 2 consists of a single line title set in 10 point, No. 524 Lining Title all caps, the author's name and address in one line in eight point caps of the body letter and the words "Member (or Honorary, or Junior) of the Society" or "Non-Member" in caps and lower case 8 point body letter. Allow 14 points between title line and author line, a six point lead between author line and "Member of the Society" line. Example:

(Sink 1 in. from point of headline)

SUPERHEAT AND FURNACE RELATIONS

(14 pt. space)

BY REGINALD PELHAM BOLTON, NEW YORK

(6 pt. lead)

Member of the Society

(16 pt. space)

76 Head No. 3 is the same as No. 2 except that there is added a one, two or three line subtitle in caps and small caps, ten point body letter. The subtitle will be set in the full page measure without

hanging indention. When subtitle runs more than one line center the last line.

(Sink 1 in. from point of headline)

COST OF HEATING STORE HOUSES

(16 pt. space)

Comparison with Cost of Dry-pipe and Calcium Chlorid Sprinkler Equipments

(14 pt. space)

By H. O. LACOUNT, BOSTON, MASS.

(6 pt. lead)

Non-Member

(16 pt. space)

CENTER HEADS

77 Center heads in the text will not usually run more than a single line and are to be set in small caps without punctuation. Example:

HEADS FOR STANDARD MACHINE SCREWS

The word "Discussion" used in Transactions to separate the paper from the discussion which follows it will be set in italic caps. Example:

DISCUSSION

78 The greatest care must be exercised in using center heads other than those above provided for. Otherwise all kinds of typographic inconsistencies will creep in. Occasionally in program work, or when a paper has two or more sections or an appendix, it becomes necessary to use a head with more weight than small caps. Three center heads may then be used sparingly and preferably in the order given:

a Caps and small caps, 10 point body letter:

Experiments of Knoblauch and Jakob

b Caps, 10 point body letter:

EXPERIMENTS OF KNOBLAUCH AND JAKOB

c Nine point No. 524 Lining Title:

EXPERIMENTS OF KNOBLAUCH AND JAKOB

SIDE HEADS

79 The only side headings to be used will be the names of those taking part in discussions. These will be inserted with a one em indenture and set in 10 point body letter roman caps without dash.

TABLES

The tables for each paper will be numbered consecutively.

80 Tabular matter is to be leaded except where in doing so it will cause an undue waste of space; for instance, where a table will go on one page if set solid and will overrun if leaded.

81 When necessary to run wording at right angles to the body of the table it shall read towards what is naturally the top of the table.

82 When the columns of a table contain decimals, the points should be lined up. When the right hand figures in a column do not line up, they should be made to line by the insertion of ciphers, except where the numbers are correct to a certain number of figures only and the insertion of ciphers would create the impression that the numbers were correct to a certain number of figures.

83 Tables will have a double rule at the top and bottom. When continued on more than one page, a single rule shall be used at the top and bottom of each page except at the beginning and end of the table. Use letters for footnote references on tabular work as figures are liable to cause confusion. Insert a space after every fifth line of figures to enable the eye to follow the line across the page.

84 Table heads will be distinguished as No. 1, No. 2, etc. Table heads will be set in the size of type used in the tables. A No. 1 head consists of a single line reading "Table 1," etc., with or without a two or three or four word title set in caps. Examples:

TABLE 3

(or)

TABLE 1 COST OF OPERATION

85 A No. 2 head is a two or three line head where the words "Table 1," "Table 2," etc., either with or without a two or three or four word title, are set in caps in one line, and the title or subtitle, as the case may be, is set in one or two lines in caps and small caps. Examples:

TABLE 1 OPERATING DATA

450 Producer Gas Power Plant

(or)

TABLE 2

Boiler Data of Principal Types of Railway Motor Cars

86 When the line of caps and small caps slightly overruns one line, make two, the top line somewhat larger than the bottom, and center both over the table.

87 Use No. 1 head and avoid the subtitle whenever possible.

ILLUSTRATIONS

88 Illustrations will be reproduced by that process which will give a satisfactory result at the least cost, every thing considered. Always favor a process which does not require redrawing. Make illustrations as small as possible to give satisfactory results.

89 Such titles as may appear on copy for illustrations will not be reproduced in the cut. Whenever possible illustrations will have titles which will be set up in type. The name of the author will not appear on cuts. Half tone cuts will be made from a 150 Mesh Screen.

90 Every effort will be made to introduce as much uniformity as possible into the size of cuts to be used on text pages. Unless there is some reason to the contrary they will be made 4 inches wide, this width to include any lettering. An exception will be made in the case of indicator diagrams which will usually be 3 inches wide. In the case of half tones any unnecessary back ground will not be reproduced. Where there is some leeway, make full page half tones 4 by 7 inches. Full page cuts will be centered in space provided for text pages.

91 On wax cuts the lettering will be made uniform with the text face. On drawings furnished for reproduction when the lettering is a radical departure from that ordinarily used on mechanical drawings and not in harmony with the text letter, it will be changed to either one of these two styles. When lettering is inserted on a wax cut covered by faint cross lines entirely remove lines at places where lettering is inserted.

92 The cut when possible should read the same way as the text. When this is not possible they should be placed so as to be read by giving the book a quarter turn in the same direction as the hands of a clock.

93 Number the illustrations of each paper consecutively. Begin a new series with each paper.

94 In planning the lay out of illustrations try to fill entirely the rectangular space. If by any rearrangement of the various parts or by replacing any portion of the lettering the matter for reproduction can be given a more rectangular shape, it should be done. Blank spaces around cuts or tabular matter do not add to the typographical attractiveness.

95 Captions for cuts will be distinguished as No. 1, No. 2, etc.

96 A No. 1 head will be either the words "Fig. 1" alone or the words "Fig. 1" followed by a two, three or four word title set in six point caps. Examples:

FIG. 3

(or)

FIG. 5 THE COLE RETURN BEND TYPE

97 A No. 2 head will be used where there is a two or three line subtitle. Set the top line including the figure number in 6 point caps and the title or subtitle line or lines as the case may be in 6 point caps and small caps. Example:

FIG. 4 LINES OF ENTROPY FOR SATURATED AND SUPERHEATED STEAM

From Peabody's Steam Tables and the Specific Heat of Superheated Steam from Knoblauch and Jakob

IMPOSITION

98 The pages of the text forms will be imposed so that the margins will be when trimmed—

For Proceedings

inside	$\frac{7}{8}$ inch
top	$\frac{3}{4}$ inch
outside	1 inch
bottom	1 inch

For Transactions

inside	$\frac{3}{4}$ inch
top	$\frac{3}{4}$ inch
outside	$1\frac{1}{8}$ inch
bottom	1 inch

99 All papers will be begun on odd numbered pages. If necessary the previous even numbered page will be allowed to go blank.

FOLDERS

100 The policy of the Society is to avoid the use of folders wherever possible on account of the considerably increased expense of publishing matter on them rather than on the text pages. This increased expense is occasioned by the fact that they can be printed only on one side, must usually be printed in less than full sheets, and require extra labor in folding and binding. When copy is offered in a form which will require reproducing on folders, every effort should be made to change it in such a way as to overcome the necessity.

101 This can be done at times by cutting up a drawing and rearranging the pieces; it can be redrawn in whole or in part if the reduction necessary to make it go on a text page will make it illegible. Excepting in complicated drawings the expense of redrawing will be less than the added expense of the folder. In redrawing it is often possible to eliminate details which have no interest in connection in the paper it is intended to illustrate. Tables can often be broken up or rearranged so as to be continued from page to page.

102 If any object of moment will be sacrificed by printing the matter in text pages, use the folder. When folders are used, every effort will be made to have them in the most convenient form. All folders will be so imposed that when opened out and the book closed, the printed matter will lie entirely without the book.

103 Folders will be inserted between the pages of the paper to which they belong. They will face to the left and be bound in at the left hand edge or at the head. Unless considerable waste is involved, impose the matter so that the folder can be read without turning the book. An insert used as a frontispiece shall face to the right.

104 Use the same kind of paper for folders as is used for the text sheets, except where a large number of folds accompany one paper when white bond paper should be used. This will reduce the bulk of the folders to a minimum.

105 Folders one page in height shall be imposed to trim 9 inches high. In width they shall be 12 inches, 18, 24, etc. In choosing a size for a folder, take the smallest size on the table below which will give the area wanted. If a folder is more than one page high, the first fold will be to bring it to $8\frac{1}{2}$ inches. Then it will be folded to bring it inside the outside edges of the book, *i.e.*, to $5\frac{3}{4}$ by $8\frac{1}{2}$. This will be done in such a manner that in opening it out and folding up, the motions will all be made in the same direction by a method known as "over and over."

106 Folders will be known as single, double, triple, etc., as to whether they are 9, 17, $25\frac{1}{2}$, etc., high. They will be known as one page, two page, etc., according to whether they have a width outside the book of one text page, two text pages, etc. Thus a double two page folder will be 17 by 18 inches in size.

107 Every folder will be surrounded by a one point rule $\frac{3}{4}$ inch from the upper and outside edges and 1 inch from the bottom of the sheet. A margin of at least $\frac{1}{8}$ inch will be allowed between this rule and the cuts, tables, etc. When possible this rule will be made a part of the cut.

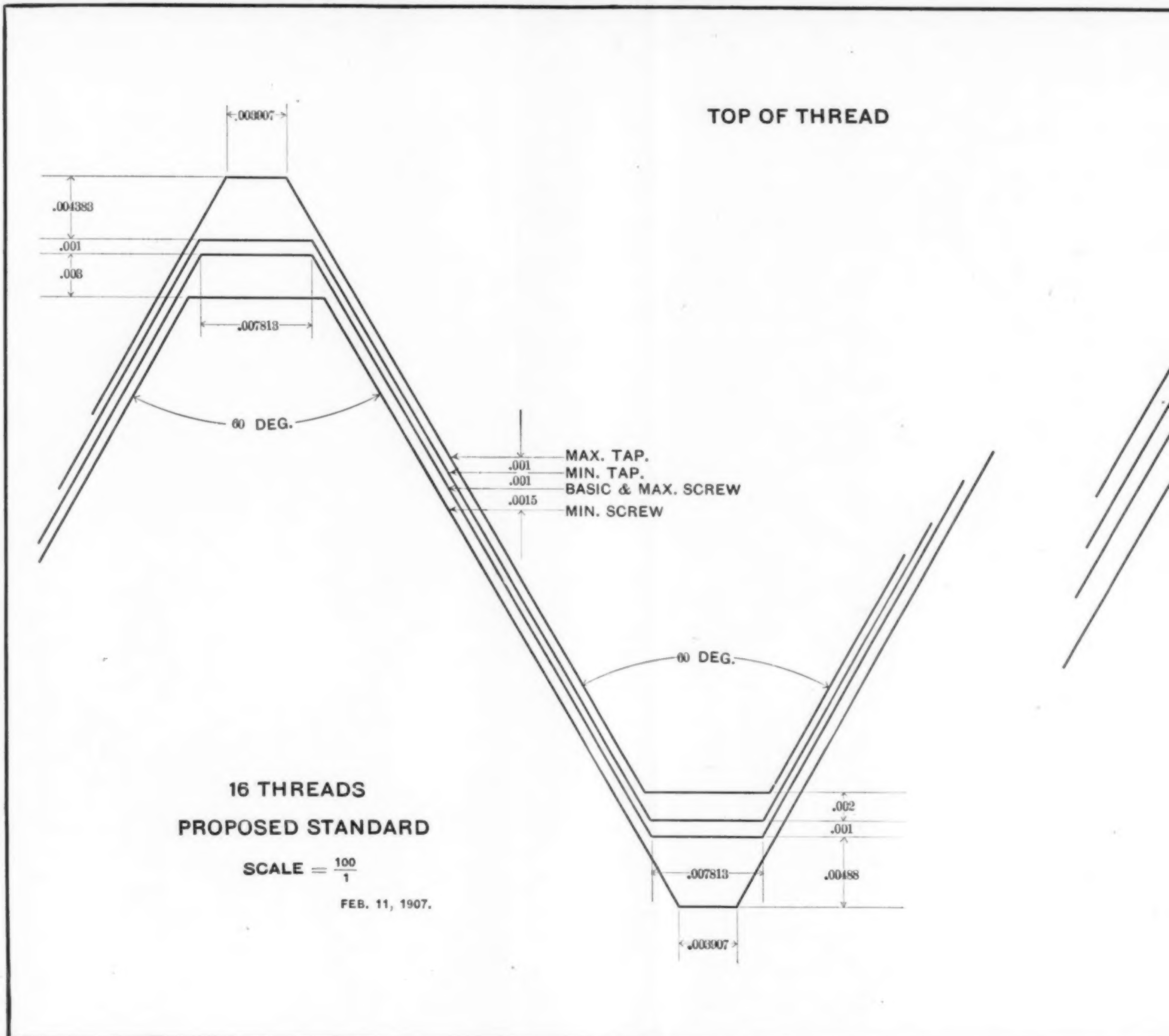
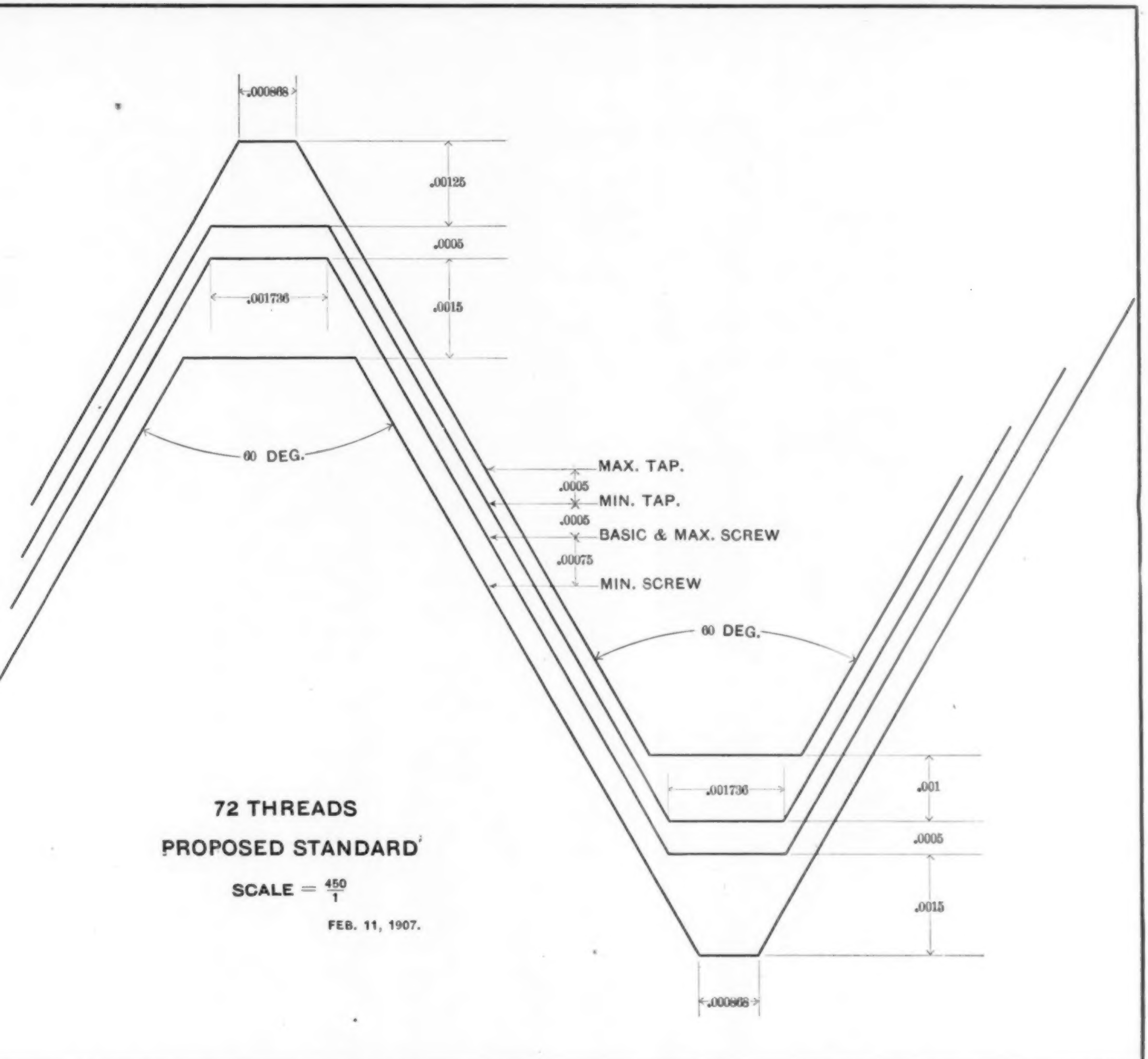


FIG. 1 DIAGRAM SHOWING FORM OF BASIC MAXIMUM AN



MAXIMUM AND MINIMUM SCREW AND TAP THREADS

	Paper Size			Size of Rule			Available Area		
	Width		Height	Width		Height	Width		Height
Single one page	12	by	9	$5\frac{1}{2}$	by	$7\frac{1}{2}$	$5\frac{1}{4}$	by	$7\frac{1}{4}$
Single two page.......	18	by	9	$11\frac{1}{2}$	by	$7\frac{1}{2}$	$11\frac{1}{4}$	by	$7\frac{1}{4}$
Single three page......	24	by	9	$17\frac{1}{2}$	by	$7\frac{1}{2}$	$17\frac{1}{4}$	by	$7\frac{1}{4}$
Single four page.......	30	by	9	$23\frac{1}{2}$	by	$7\frac{1}{2}$	$23\frac{1}{4}$	by	$7\frac{1}{4}$
Double one page	12	by	17	$5\frac{1}{2}$	by	16	$5\frac{1}{4}$	by	$15\frac{3}{4}$
Double two page......	18	by	17	$11\frac{1}{2}$	by	16	$11\frac{1}{4}$	by	$14\frac{3}{4}$
Double three page.....	24	by	17	$17\frac{1}{2}$	by	16	$17\frac{1}{4}$	by	$15\frac{3}{4}$
Double four page......	30	by	17	$23\frac{1}{2}$	by	16	$23\frac{1}{4}$	by	$15\frac{3}{4}$

108 The distance between folds, reading from left to right, will be, from binding edge to first fold, $5\frac{3}{8}$ inches

from first fold to second fold. $4\frac{1}{4}$ inches

from second fold to third fold, $4\frac{1}{8}$ inches

from third fold to fourth fold, 4 inches

109 Every folder will have a head line set in 8 point caps. The first half, giving the name of the Society and the publication with volume and number, will be set on the left hand side and the second half, giving the name of the paper and the number of the folder, will be set on the right hand side. Use a 2 point lead between headlines and enclosing rule.

110 When there is more than one folder connected with a page, the number will be printed on the back. This will be placed $\frac{1}{2}$ inch from the top and $\frac{1}{2}$ inch from the right hand side on the section which faces up when the book is opened and the folder folded. The word folder with the number will be set in ten point No. 524 Lining Title. For illustration of the various specifications covering folder see specimen folder herewith.

REPORTS OF COMMITTEES

111 The first paragraph of all committee reports will consist of a statement as to where the committee was appointed and the purpose of its appointment in the following form:

"The Committee, appointed by the Society in December 1903, to suggest a Standard Tonnage Basis for Refrigeration, and reappointed in 1904 to recommend a method for measuring the quantity of refrigerating fluid evaporated in the refrigerator, and to prepare

a code of rules for conducting tests of refrigerating machines, has the honor to present the following report."

112 The report will be signed "Respectfully submitted" with the names of the committee in caps and small caps, the chairman indicated by the word "Chairman" in italic caps and lower case immediately after his name and the list bracketed with the word Committee also in italic caps and lower case. Example,

Respectfully submitted,

PHILIP DcC. BALL,
E. F. MILLER,
A. P. TRAUTWEIN, *Committee*
G. T. VORHEES,
D. S. JACOBUS, *Chairman*

PROCEEDINGS

113 The title of each issue of Proceedings will be printed on the bone set in 10 point Lining Title No. 524 to occupy a length of 5⅞ inches; to be centered both ways, and to be printed so that it can be read when the book is lying face up.

The cover will be scored for this back.

COVER

114 The cover page will be surrounded by a border made up of a 4 point rule on the outside and a 1 point rule on the inside, separated by a 4 point space. This border will be 5 by 8 inches, leaving a ½ inch margin all around. Inside the border and ¼ inch from top and side will be placed (on the left hand side) the volume and (on the right hand side) the number set in seven point Lining Title Cap No. 524.

115 The name of the Society in two lines with 12 points between them set in 12 point Lining Title Cap No. 524 will be enclosed in a 1 point box rule the latter placed 1¼ inch below the border and ⅝ inch from either side. The word Proceedings set in 24 point Lining Title Cap No. 524 will be centered ½ inch below the panel. The month and year of issue set in ten point Title Cap No. 524 will be centered and placed ⅜ inch below Proceedings.

116 The table of contents will be set in 8 point to a 4¼ inch measure. The main heads will be set in caps and small caps and separated by a two point lead. The sub-heads will be set in caps and lower case and solid. One dot to the em open leaders will be used. The table

PROCEEDINGS A. S. M. E. VOL. 28. No.8 APRIL, 1907

PROCEEDINGS A. S. M. E. VOL. 28. No.8 APRIL, 1907

VOLUME 28 NUMBER 8

DEDICATION OF BUILDING, APRIL 16-19, 1907

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PROCEEDINGS

APRIL 1907

CONTENTS

INDIANAPOLIS MEETING, MAY 28-31, 1907

APRIL 1907 VOL. 28 No. 8

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PROCEEDINGS

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of contents will be centered between the month and year line and the bottom of the rule border not approaching nearer the former than ½ inch. Where it will not go in this space it must be abbreviated in such a way as to make it go.

117 No other type will be used on the cover except a line announcing a meeting, not longer than 3½ inches, set in 9 point Lining Title No. 524 and midway between the The American Society of Mechanical Engineers panel and the top line of the border. Where two meetings are being promoted at one time, a second line of the same maximum length and size of type may be placed between the bottom of the table of contents and the bottom of the ruled border, provided there is a space at least ½ inch wide in which to put it.

TITLE PAGE

118 The title page will be surrounded by a 1 point box rule, making a panel 4⅛ by 7½ inches. Inside the border and ⅜ inch from top and side will be placed, on the left hand side, the month and year of issue, and on the right hand side the volume and number, both set in 7 point Lining Title cap No. 524.

119 The name of the Society in two lines of equal length with 10 point space between set in 10 point Lining Title Cap No. 524 will be centered and placed 1$\frac{3}{16}$ inches below the border. The word Proceedings set in 24 point Lining Title Cap No. 524 centered will be placed $\frac{11}{16}$ inch below the name of the Society.

120 The imprint will consist of four lines, set in seven point Lining Title Cap No. 524.

The American Society of Mechanical Engineers
2427 York Road, Baltimore, Md.
Editorial Rooms and Library
29 West 39th Street, New York.

121 Between lines 1 and 2 and 3 and 4 place 4 points, and between 2 and 3, $\frac{3}{16}$ inch; between line 4 and the border, $\frac{5}{16}$ inch.

122 Center a 1¼ inch publisher's imprint between the word Proceedings and the imprint.

123 Put the following line immediately below the border in 6 point caps and lower case body letter:

"Entered at the Post Office in Baltimore, Md., as second class matter under the Act of July 16, 1894."

This page will be imposed as provided for text pages. Example herewith.

TEXT HEADING

124 The heading on the first text page will be sunk 1 inch from the head and will consist of the words "Proceedings of The American Society of Mechanical Engineers" divided in four lines; line one set in 14 point, line two in 7 point and lines three and four set in 12 point No. 524 Lining Title.

125 Put $\frac{1}{4}$ inch space between line one and two and between two and three; a 6 point lead between three and four, and $\frac{1}{4}$ inch between line four and the first of the two four point double fine line rules which enclose the date line. These rules will be $\frac{5}{16}$ inch apart. Insert midway between them, on the extreme left, the volume number (Vol. 28); in the middle, the month and year; and on the extreme right, the number (Number 10) Volume and number will be set in 7 point No. 524 Lining Title caps, and the month and year in 9 point, same face. Example:

PROCEEDINGS

OF

THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS

VOL. 28	JUNE 1907	NUMBER 10

RECORDS OF CANDIDATES FOR MEMBERSHIP

126 Use No. 3 head. Set the lines "To be voted for as Members" etc., in 10 point cap and small caps body letter, allow $\frac{1}{4}$ inch space between each record. Records are to be set in 8 point.

NEW BOOKS

127 Use No. 1 head. The title of each book will be set in caps and small caps 10 point, the author, in caps and lower case: the publishers in italic caps and lower case.

128 The contents when given will be set in 6 point preceded by the word contents in italics. Example,

NEW BOOKS

DENATURED OR INDUSTRIAL ALCOHOL. By Rufus Frost Herrick. *John Wiley and Sons, New York*, 1907. 8vo, 512 pp., 163 figures. Cloth, $4.

Contents, by chapter headings: Composition, History, and Use of Denatured Alcohol; The Manufacture of Alcohol; the Distillation and Rectification of Alcohol; Alcoholometry; The Cost of Alcohol and of Alcohol Distributing Plants; Alcohol as an Illuminant; The Fuel Value of Alcohol Compared with the Other Usual Liquid Fuels; Alcohol as a Source of Power; Laws and Regulations for Denatured Alcohol in the United States.

Appendix: The U. S. Regulations and Instructions Concerning the Denaturation of Alcohol and the Handling and Use of Same Under the Act of Congress of June 7, 1906; Amendments to the Act of Congress of June 7, 1906; Report of the British Departmental Committee on Industrial Alcohol, Presented to both Houses of Parliament by Command of His Majesty, March 23, 1905; Appendices from Minutes of Evidence taken before the British Departmental Committee on Industrial Alcohol, Presented to both Houses of Parliament by Command of His Majesty. Abstract from British Revenue Act, 1906, as to Spirits Used in Art, Manufactures, etc., and Supplemental Amendments of the Spirits Act; Bibliography of Denatured Alcohol and Books of Reference; List of Patents Relating to the Manufacture of Alcohol and Alcohol-Distilling Apparatus.

DISCUSSION

129 For head for this section use the word "Discussion" set in 14 point No. 524 Lining Title. For each of the pages for which discussion is presented use the title set in 9 point No. 524 Lining Title with the author's name and the number of Proceedings in which the paper appeared in one line in 8 point caps and small caps. Between the word "Discussion" and the first headline there will be ¼ inch space.

130 The name of the author of the discussion will be set as a sidehead in caps and small caps. When the name is that of the author of the paper it will be made to read "THE AUTHOR."

131 Pieces of discussion of the same paper will follow one after the other. Between the last piece of discussion on one paper and the head of the next there will be a ⅜ inch space. Between the head and the author line and between the author line and the first line of the discussion there will be $\frac{3}{16}$ inch space.

132 The headline of page devoted to discussion will be the same headline as used with the paper to which the discussion belongs. The headline on a page where discussion for two different papers appear will refer to the paper the discussion of which begins on that page.

133 In numbering the paragraphs of a piece of discussion, continue the series already in use for the paper to which it belongs so that when put in Transactions these numbers will not have to be changed, or if changed will have the same number of figures as the new ones.

TYPOGRAPHY OF TRANSACTIONS

TITLE PAGE

134 The title page for Transactions will be much like that for Proceedings. The volume, number and date will be left out of the upper corners and the volume set in front No. 524 Lining Title will be centered $\frac{3}{8}$ inch below the word Transactions which takes the place of Proceedings. There will be placed $\frac{5}{8}$ inch below the volume number two lines giving the meetings contained in the volume set in 8 point cap body letter.

The imprint reading

NEW YORK	in 8 point caps
PUBLISHED BY THE SOCIETY	in 10 point caps
No. 29 WEST 39TH STREET	in 6 point caps
1906	in 8 point caps

will be put at bottom of page. Give 8 points between the imprint and the bottom rule.

Center a $1\frac{1}{4}$ inch seal between the imprint and the last meeting line.

HALF-TITLE PAGE

135 Each meeting will be preceded by a half-title page. It will consist of the words "New York Meeting" set in twelve point No. 524 Lining Title and the words "Held on December 3, 6, 7 and 8, 1905, being the annual meeting and the fifty-second meeting of the Society" set to a $3\frac{1}{8}$ inch measure in 9 point Lining Title cap No. 524. There will be a space of $1\frac{1}{2}$ inches between the top line and the bottom section. It will be centered in the text page space. Example,

NEW YORK MEETING

HELD ON DECEMBER 3, 6, 7 AND 8, 1905 BEING THE ANNUAL MEETING AND THE FIFTY-SECOND MEETING OF THE SOCIETY

HEADINGS

136 The head for the Proceedings of each meeting and for each page and section, such as "Memorial Notices," will be exactly like those provided for Proceedings, except that each one will be preceded by a number set in 8 point Engravers Roman. This number will be set 14 point above the title line. The heads will be sunk one inch.

PRINTED FORMS

137 Except where there is a strong reason against it all forms shall be 8½ by 11 and 5½ by 8½ inches in size and set to read the short way.

CIRCULARS, ADVERTISING MATTER, ETC.

138 Except when there are strong reasons against it advertising matter, circulars, etc., will be 5½ by 8½ inches or 5½ (open 11) by 8½ inches, or 8½ by 11 inches. Each of these circulars will fold to go in SE 2GCW.

APPENDIX

STYLE SHEET FOR PROFESSIONAL RECORDS

A condensed Style Sheet in which the rules for abbreviations, punctuation, capitalization, order and form, and the use of numerals which specially apply to Professional Records is given for the convenience of those who prepare copy.

These rules, except in a few instances where their application cannot be extended beyond Professional Records, are embodied under the proper headings of the general Style Sheet.

ABBREVIATIONS

1 Avoid symbols wherever possible. Never use the characters (′) or (″) to indicate feet and inches, or minutes and seconds as periods of time.

2 Use abbreviations only after a noun denoting a definite quantity. Example: The power plant has a capacity of 10 h.p. not 10 horse power: but, The capacity of the plant, in horse power, is ten.

3 Do not abbreviate abstract or descriptive words. Example: Horizontal return tubular boilers, not h.r.t. boilers.

4 Use lower case characters for abbreviations. An exception to this rule will be made in the case of words spelled normally with a capital. Example: B.t.u. not b.t.u. or B.T.U. (British thermal unit); U. S. gal. (United States gallon); B. & S. gage (Brown and Sharpe gage).

5 Use a period after each abbreviation. In a compound abbreviation, do not use a space after the period. Example: i.h.p. and not i. h. p. (indicated horse power).

6 Use a hyphen to connect abbreviations in cases where the word would take a hyphen if written out in full. When a hyphen is used, omit the period immediately preceding the hyphen. Example: 3 kw-hr. and not 3 kw.-hr. (3 kilowatt-hours).

7 Use all abbreviations in the singular. Example: 17 lb. and not 17 lbs. (17 pounds); 14 in. and not 14 ins. (14 inches).

8 Spell out the name of the month in giving the date of birth.

9 Write January 25, not January 25th or the 25th of January.

10 Do not use st, d, rd, or th, with numerals.

11 Spell out the names of companies, railroads, etc., using the "short and" (&) only between proper names. Examples: Brown & Sharpe Mfg. Co., Norfolk & Western R. R., but The American Smelting and Refining Co.

12 Abbreviate Company (Co.) in firm names. Example: John Brown & Co.

13 In giving a title, use Dr., Prof., Genl., etc. where initials or full name is given: spell out where surname only is given. Examples: Genl. James P. Gordon, but General Gordon.

14 Abbreviate States and Territories according to list.

15 Use Year Book abbreviations as far as possible.

16 Do not abbreviate company names further than authorized by standardized list of abbreviations.

American .... Am.	Architect .... Arch.
Assistant .... Asst.	Associate .... Assoc.
Attorney .... Atty.	Avenue .... Ave.
Brothers .... Bros.	Building .... Bldg.
Captain .... Capt.	Charles .... Chas.
Chemist .... Chem.	Company .... Co.
Consolidated .... Consol.	County .... Co.
Department .... Dept.	East .... E.
Electric .... Elec.	Engine .... Eng.
Engineering .... Engrg.	Engineer .... Engr.
Expert .... Exp.	Chief Engineer .... Chf. Engr.
Civil Engineer .... Cv. Engr.	Constructing Engineer .... Constr. Engr.
Contracting Engineer .... Contr. Engr.	Electrical Engineer .... Elec. Engr.
Heating Engineer .... Heat. Engr.	Hydraulic Engineer .... Hyd. Engr.
Industrial Engr. .... Ind. Engr.	Marine Engineer .... Mar. Engr.
Mechanical Engineer .... Mech. Engr.	Mining Engineer .... Min. Engr.
Refrigerating Engineer .... Refrig. Engr.	Resident Engineer .... Res. Engr.
Sales Engineer .... Sales Engr.	Superintending Engineer .... Suptg. Engr.
Equipment Engineer .... Equip. Engr.	Foundry .... Fdy.
General .... Gen.	George .... Geo.
Honorable .... Hon.	Incorporated .... Inc.
Inspection .... Inspc.	Inspector .... Inspr.
Institute .... Inst.	Instruction .... Inst.
Insurance .... Ins.	International .... Internatl.
James .... Jas.	Lieutenant .... Lieut.
Limited .... Ltd.	Locomotive .... Loco.
Machine .... Mch.	Machinery .... Mchy.
Manager .... Mgr.	Manufacturer .... Mfr.
Manufacturing .... Mfg.	

Master Car Builder	M.C.B.
Master Mechanic	M.M.
Mechanical	Mech.
Mining	Min.
Motor Power	M.P.
National	Natl.
North	N.
Patent	Pat.
Place	Pl.
Pneumatic	Pneu.
Post Office	P. O.
President	Pres.
Professor	Prof.
Proprietor	Prop.
Railroad	R.R.
Railway	Ry.
Representative	Rep.
Secretary	Secy.
South	S.
Street	St.
Superintendent	Supt.
Thomas	Thos.
Technical	Tech.
Treasurer	Treas.
United States	U. S.
U. S. Army	U. S. A.
U. S. Navy	U. S. N.
University	Univ.
Vice-president	V. P.
West	W.
William	Wm.
Works	Wks.

AUTHORIZED ABBREVIATIONS OF STATES AND TERRITORIES

Ala.	Ky.	N. Y.
Alaska	La.	O.
Ariz.	Mass.	Okla.
Ark.	Md.	Oreg.
Cal.	Me.	Pa.
Colo.	Mich.	R. I.
Conn.	Minn.	S. C.
Del.	Miss.	S. Dak.
D. C.	Mo.	Tenn.
Fla.	Mont.	Tex.
Ga.	N. C.	Utah
Ia.	N. Dak.	Va.
Idaho	Neb.	Vt.
Ill.	Nev.	Wash.
Ind.	N. H.	W. Va.
Ind. Ter.	N. J.	Wis.
Kan.	N Mex.	Wyo.

PUNCTUATION

1 After the several divisions of the record, observe the following punctuation

Born, (comma)
Education: (colon)
Apprentice: (colon)
Drafting room: (colon)
Shop Experience: (colon)
Other Engineering work: (colon)
Present position, (comma)
References: (colon)

2 Between the different sub-divisions of the five main divisions use the comma and semi-colon. Never the colon or period. Examples:

Shop experience: Pattern work, structural steel work, setting up engines.

Other Engineering work: Lecturer of Mechanical Engineering Queen's University, Kingston, Ontario, 1902–1904; Assistant professor experimental engineering, Columbia University, 1904–1906.

3 Between the month and year, when no date is given, leave out the comma. Example: June 1906, not June, 1906.

4 Place a comma after the title of the position. Example: Chief draftsman, The Allis-Chalmers Company.

5 Do not enclose in quotation marks the names of ships, railway cars, engines, periodicals, etc.

CAPITALIZATION

1 Set the name of the candidate in caps.

2 Do not capitalize titles except when used before personal names.

3 Use capital initial letter for first word of the different divisions of the record. Example: Drafting room: Chief draftsman for Standard Car Company.

4 In general, leave out capitals wherever possible. Use them for proper names only unless there is some good reason.

ORDER AND FORM

1 Write, Wilmington College, B.S. 1891, M.S. 1904 not B.S. Wilmington College, 1891.

2 Place the work first—date or dates of the work second. Example: Engaged in construction of elevators 1894–1896, not 1894–1896 engaged in construction of elevators.

3 Use 1894–1896, not 1894–96.

USE OF NUMERALS

1 Do not begin a sentence with figures.

2 Spell out all numbers from one to twelve.

Exceptions (a) Do not spell out improper fractions. Example: $1\frac{1}{2}$, $2\frac{3}{4}$ etc. (b) When a number below twelve is followed by an authorized abbreviation use the figures. Example: 2 ft., 6 oz., 1 in. etc.

3 If a vague statement is made, as when the word "about" is used, write out the number.

4 In a series of connected numerical statements where precision is implied, use numerals only: as "2 foremen, 7 masons, 8 laborers."

5 Use numerals in such expressions as 7-story building, and 3-mile railway, and when one number immediately follows another, spell out the smaller, as six 4-inch bolts.

6 Use the word "by" instead of the letter x in giving dimensions. Example: 8 by 12 inches, not 8 x 12 inches.

MEMORIAL CHARLES HAYNES HASWELL

By FREDERICK R. HUTTON, NEW YORK
Member of the Society

In the death of Mr. Haswell on May 12, 1907, in New York a unique figure has been removed from the stage on which engineering history is being enacted. His position was noteworthy, not only by reason of his age and continued activity, but from the fact that he took part in so many beginnings of the modern era and was preëminent in them.

Horatio Allen ran the first locomotive on this side of the Atlantic when Mr. Haswell was 20 years old; Robert Fulton's first trip of the Clermont took place only two years before his birth. Mr. Geo. W. Copeland and B. F. Isherwood were his associates in the design of marine engines: John Ericsson came to the front when he was in the full activity of his work. It was given to him to span the entire history of the introduction of steam into the U. S. Navy, from its beginnings as a modest auxiliary to sail power up to his service as Engineer-in-Chief, and to see the disappearance of power-mast and rigging before the end of his life.

Mr. Haswell was born from English parentage stock in North Moore Street in New York on May 22, 1809. Had he lived ten days longer he would have been 98 years old. As a boy on the docks he saw the early triumphs of the Robert Fulton idea, and remembered the appearance of the Fulton the First, or Demologos, in the waters of New York harbor, and watched her career from her launching in 1814 to her destruction by a magazine explosion in June 1829. This boat was the first steam war vessel in the world.

From 1807 to 1835 a maritime service of over seven hundred vessels had grown up on rivers and lakes, with some coastwise vessels, few of them larger than a modern tug. Mr. Mahlan Dickerson, then Secretary of the Navy, approved a recommendation of the Board of Navy Commissioners that a person be secured as "engineer; his services will be much wanted in superintending the construction and arrangement of the engines and boilers" of a vessel then being constructed at the New York navy yard, and in July 1836 Mr. Haswell was appointed, on his application for the place, to the position of chief

engineer of the Fulton the Second. This was the first creation of such a position: Mr. Haswell had designed the engines and Mr. Chas. W. Copeland[1] the boilers. At this time he was chief engineer of the West Point Foundry Association.

Mr. Haswell had the usual classical education which was the only one possible in his day, and entered in 1828 the works of James P. Allaire. The Allaire Works was a pioneer in the days of New York's engineering supremacy, sharing with the Novelty Iron Works, The Etna Works, Franklin Forge, the Fulton, Morgan, the Quintard and the Delamater Iron Works the opportunities of the rapid marine development of that day. The East River also had extensive ship yards; among them those of Wm. H. Webb, and Henry Steers.

Mr. Haswell became chief draftsman and designer of the Allaire Works and in 1837 was responsible for the first steam launch or steam yacht, which he called the "Sweetheart." He lengthened the gig of the sloop of war Ontario and fitted to it an engine and boiler, converting it into a steam launch.

The engines of the Fulton were double, each 50 by 108 inches, and turning a separate side wheel of 22 feet 9 inches diameter and 11 feet face. These engines were on the spar deck; the cranks and shaft were of cast iron.

In 1839 two naval Boards, one of commodores and the other of constructors, the latter having Mr. Haswell as one of the members, started the construction of two side-wheel steam frigates, the Mississippi and Missouri. Mr. Copeland designed the engines and boilers, in his relation as consulting engineer, with a title of Principal Engineer, for the Board of Navy Commissioners, and Mr. Haswell was detached from the Fulton to work over the details of construction.

It was in connection with these boilers that Mr. Haswell laid out the shape and dimensions of each plate for the first time in history, using the methods of the mould-loft for this purpose. The boilers were of copper as was usual in those days. The Mississippi had two side-lever engines with cylinders 75 by 84 inches; the Missouri had two inclined engines 62½ by 120 inches. The vessels were of wood and were completed in 1842. After serving with Mr. Copeland on the designs of the Michigan, Mr. Haswell returned to the Missouri, as her chief engineer.

On August 31, 1842, very largely at Mr. Haswell's initiative, was

[1]Mr. Copeland was treasurer of The American Society of Mechanical Engineers for many years and later vice-president. On his death he gave the Society an option on the purchase of his library, and much valuable historic literature came to it in this way.

approved the act of Congress, creating a corps of engineers and assistants and providing for a "skillful and scientific engineer-in-chief" and on Oct. 3, 1844 Mr. Haswell was appointed to this post. In 1845 the engineer corps was reorganized under his direction and along lines which remained essentially unaltered until the consolidation with the line of the Navy, in 1899. This was the same year that the Naval Academy was started

A Mr. Gilbert L. Thompson, a lawyer and business man, appointed in 1842 on the passage of the act creating the position of engineer-in-chief to serve in that capacity, was responsible for an order replacing the vertical 7 foot smoke stack of the Missouri by two flues each of 3 feet 6 inches. One of these was led horizontally under the deck to the wheel-house on each side, and discharged there the products of such combustion as could be secured. The idea was to use the suction of centrifugal action due to the revolving wheel, and to dispose of and conceal the smoke by entangling the carbon with the water raised by the paddle-floats. Not only were the flues too small, but the boilers were abaft of the engines and shaft, compelling the gases to go against the current due to the motion of the vessel. Mr. Haswell, as chief engineer of the ship, protested against the change proposed but was over-ruled; and when the scheme failed most signally, he was made a sort of scape-goat and suspended from duty. In recognition of the injustice, however, his restoration to duty and to the ship was offered to him on condition that he would apologize for his error. He refused the opportunity tendered to him in words which have been often quoted: "I would rather suffer injustice from another than be unjust to myself."

Mr. Haswell on leaving the Navy was at once employed on designs for engines for the U. S. Revenue service, and in December 1843 was called back to be engineer-in-chief of the Navy, and in October of the the next year Mr. Thompson's name was dropped from the list and Haswell's regular service began. The Missouri was burned in 1843 from the breakage of a carboy of turpentine; and it is to be noted that a request of the year before from Haswell for a lead tank for the turpentine had been refused by the authorities. The Mississippi, her sister-ship, was Commodore Perry's flagship in the expedition to Japan, and was the ship where the incident is said to have occurred emphasizing that "Blood is thicker than water" in the Pei-Ho river engagement.

In the early years of Mr. Haswell's service, 1842–1849, he saw the experiments tried with the Hunter scheme of placing the paddle wheels on vertical axes, the idle arc of their circumferences being

within the hull surface, so that only the operative arc projected. In 1842 the beginnings were made upon the Stevens Battery; in 1842–1845 the Princeton embodying John Ericsson's screw propeller was ordered and built by the efforts of Capt. Richard P. Stockton. This was the first screw steam war vessel and was also the first one to have all machinery under the defensive water line. She was designed for anthracite coal to eliminate the betrayal by smoke; had forced draft from blowers, a telescopic smoke stack, and had Ericsson's vibrating piston engine, with a direct connection to the draft without the gears which had been advocated by other designers.

It was in 1841–1842 that the design was made by Mr. Copeland of the engines and boilers of the Michigan for use on the Great Lakes service. There were two inclined engines 36 by 96 inches and the hull was of iron, the first iron ship made. When the writer last visited the vessel at Erie, Pa., these engines were still in use and in excellent working order.

In 1846, Mr. Haswell suggested the practice of hanging slabs of zinc in the boilers of vessels using seawater containing hydrochloric acid as a means of neutralizing galvanic action between copper and iron in such acid solution. Such plates were put in the Princeton's boilers and in those of the Legare of the Revenue service. This was nearly thirty years before this plan was tried in England as a new invention, and was kept up in coastwise practice until the use of distilling outfits diminished its significance.

In 1847 a Board of which Mr. Haswell was a member decided upon four vessels: the engines of the Susquehanna, which resulted from their decision, were designed by Mr. Copeland, and those of the Powhatan, by Mr. Haswell. The Susquehanna had inclined engines 70 by 120 inches and 31 foot wheels; the Powhatan's were of the same cylinder volume but had vertical air pumps, and built up wrought iron box-girder frames. The Powhatan had Worthington pumps as auxiliaries, and the first donkey-boiler for port use. The drawings were made by Mr. Haswell's own hands and are noteworthy in that they were built up from details without a previous general assembly drawing.

The two other ships were the Saranac and San Jacinto, the engines of the latter being designed by Mr. Haswell. The Saranac was a paddle wheel boat, the other screw driven. The engines driving the screw were 62½ by 50 inches, placed athwartship, and inclined upward and outward. Back-acting connecting rods transmitted the motion to the crank shaft which lay between the head ends of the cylinders. The boilers were still of copper; the propeller shaft 20 inches to one side of the center line, so as to avoid the stern-post.

Mr. Haswell protested again against some of the limitations imposed upon his design by the Board, and the difficulties so imposed compelled some details which could not be defended on any other grounds. The public controversy resulted in the appointment of a civil engineer of prominence to the position of Engineer-in-Chief of the Navy, a Mr. Charles B. Stuart. Mr. Haswell was made chief engineer of the San Jacinto and Mr. B. F. Isherwood, who had been with Mr. Stuart on the Erie Canal was detached from the Light-house Board and made technical assistant to the latter. The propriety of assigning Mr. Haswell to the care of engines which he had himself designed, and in whose success he would be keenly interested, dictated this assignment.

Unfortunately Mr. Haswell was then suffering from physical disability brought on by a torpid liver and chronic dyspepsia, and had stated that he ought to resign. He was persuaded to defer action until his arrival in Spain where if he had not improved, he would receive word which would withdraw him on sick-leave. By a double combination of misunderstandings, and resulting inaction by friends of Mr. Haswell and by the Secretary of the Navy, no such relief was awaiting him. He was on the sick list and relieved from duty, but was refused his detachment from the ship; sick, disgusted and depressed, he left the vessel and returned to his own country. This was technically met by official action severing him from the Navy on May 14, 1852. Legislative action was proposed in 1859 to confirm him as a chief engineer and was again brought up in February, 1907, to secure him an honorable discharge. Mr Haswell took little or no interest in these matters himself.

On returning to New York Mr. Haswell entered civil life and engaged actively in his professional work. He became a member and was President of the Common Council of the City; a trustee of the New York and Brooklyn Bridge which was the first of the series; surveyor of steamers for Lloyd's and the Marine Underwriters of New York, Boston and Philadelphia; consulting engineer for the Health Department, Quarantine Commission, and Department of Public Charities and Correction. He designed and superintended the erection of the long crib at Hart's Island in the harbor and the filling in of Hoffman's Island. He designed and superintended the construction of many commercial vessels, and some heavy foundations for lofty buildings. He was one of the consulting engineers of the Board of Appointment of New York, and at his death left uncompleted the extensive construction and improvement work in progress at Riker's Island. As lately as in 1905–1906 in severest

winter weather he used to go down frequently to this to give it his personal supervision.

Apart from his earlier service to the U. S. Navy, Mr. Haswell was probably best known by the preceding generation by reason of his "Pocket-Book." It antedated the first Trautwine and Searle's in the civil engineering field and was a treasure house of practical information not to be found in encylopedias and text books of that day. It was the progenitor of the more comprehensive Kent and Suplee of the current period, but the author kept it fresh, and last year it appeared in a seventy-second edition. Over 146 000 copies have been sold during its continuance. Mr. Haswell also wrote "Reminiscences of an Octogenarian," covering old New York from 1816 to 1860.

Recognition came to Mr. Haswell from many directions. In 1853 on a visit to Russia, the Emperor Nicholas gave him a diamond ring. He was an Honorary Member of The American Society of Mechanical Engineers and honorary or life member of many other organizations, such as The Institution of Civil Engineers of Great Britain, The Institute of Naval Architects of Great Britain, The American Society of Civil Engineers, The Society of Naval Architects and Marine Engineers, the Engineers Club of Philadelphia, the Society of Municipal Engineers of New York, the American Institute of Architects, The New York Academy of Sciences, the New York Microscopical Society, the Society of Authors, The Boston Society of Civil Engineers and others. In 1897 he was a representative and delegate to the International Congress in London from the Society of Naval Architects and Marine Engineers, where his age, his reputation and his charming personality made him easily the most remarkable figure in the gathering, and great attention was paid to him as the Nestor of the profession. He was a member of the Engineers' Club, the American Yacht Club, and was dean and oldest member of the Union Club of New York City. He was singularly interested, for an old man, in the doings of the young people, and sympathetic and concerned in the activities of the old Dutch Reformed Church which he attended regularly. His spare figure, with the pink carnation in the coat lapel, was always to be seen in his place until the increasing disability of his last year broke up the habit.

He was greatly interested in the planning and purposes of the Engineering Building in New York for the uses of the Societies. It occurred to one of the Building Committee that it would be both worth while and pleasant to have him present at the informal function of the laying of the corner stone by Mr. and Mrs. Carnegie in

May 1906. A steam motor car, using superheating and partial condensation in a compound engine was used to convey him from his home and back, and it proved that this was his first motor vehicle ride. It added interest that principles for which he had stood in his earlier days should be embodied in the motor which bore him.

His death followed an accidental fall in the dining room of his own home on May 12, 1907. An interesting photograph, in which Haswell and Melville—the first and then active Engineers in Chief—appear, illustrates the account in the Transactions of the unveiling of the monument to Robert Fulton in Trinity Churchyard.

Later, when Admiral Melville had retired, a photograph of Admiral Rae and Mr. Haswell was taken in connection with a reception at the Engineers' Club in New York, which has been regarded as very successful.